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FARMERS' BULLETINS

Nos. 876–900

WITH CONTENTS AND INDEX.

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CONTENTS.

FARMERS' BULLETIN NO. 876.—MAKING BUTTER ON THE FARM. Page.

- Extent of farm buttermaking 3
- Quality and preparation of the cream 3
- The process of churning 10
- Washing, salting and working the butter 14
- Butter packages 17
- Difficult churning 18
- Equipment for farm buttermaking 20
- Plan of dairy house 21
- Summary of steps in making butter on the farm 22

FARMERS' BULLETIN NO. 877.—HUMAN FOOD FROM AN ACRE OF STAPLE FARM PRODUCTS.

- Food value of crops 6
  - Corn 6
  - The sweet potato 6
  - The Irish potato 7
  - Rye 7
  - Wheat 7
  - Rice 7
  - The soy bean 7
  - The peanut 8
  - Oats 8
  - The navy bean 8
  - Cowpeas 9
  - Buckwheat 9
- Live-stock products 9
  - Milk 9
  - Cheese and butter 10
  - Pork 10
  - Other animals 10

FARMERS' BULLETIN NO. 878.—GRAINS FOR WESTERN NORTH AND SOUTH DAKOTA.

- Description of the section 3
- Growing the grain crops 6
- Grain crops and varieties 10
- Recommended varieties of small grains 21

FARMERS' BULLETIN NO. 879.—HOME STORAGE OF VEGETABLES.

- Reasons for storing vegetables 3
- Types of storage 4
- Storage of various vegetables 15
- Storage of apples 22

FARMERS' BULLETIN NO. 880.—FUMIGATION OF ORNAMENTAL GREENHOUSE PLANTS WITH HYDROCYANIC-ACID GAS.

- Equipment necessary for fumigation 3
- Preparation of greenhouse for fumigation 4
- Method of computing the cubical contents of oven and three-quarter span greenhouses 5
- Time for fumigation 5
- Chemicals required for fumigation 6
- Determining the amount of cyanid to be used 6
- Chemical formula to be employed 8
- Mixing the chemicals 8
- Number of generators to be employed 9
- Exposures 9
- Ventilation after fumigation 9
- Effects of weather and other conditions on fumigation 9

FARMERS' BULLETIN NO. 880.—FUMIGATION OF ORNAMENTAL GREENHOUSE PLANTS WITH HYDROCYANIC-ACID GAS—Continued.

Page.

Advisability of a fumigation box 10
How greenhouses become infested with insects 10
Cost of hydrocyanic-acid gas fumigation 11
Precautions 11
Guide to greenhouse fumigation 12

FARMERS' BULLETIN NO. 881.—PRESERVATION OF VEGETABLES BY FERMENTATION AND SALTING.

Advantages of the methods 3
General principles of the methods 3
Equipment needed 4
Fermentation with dry salting 5
Fermentation in brine 9
Salting without fermentation 11
Care of storage of fermented and salted products 12
Preparation of fermented and salted vegetables for the table 12

FARMERS' BULLETIN NO. 882.—IRRIGATION OF ORCHARDS.

Selection of lands for orchards 3
Typical water supplies for orchards 4
Clearing and grading land for fruit 7
Locating the three rows 9
Methods of irrigating orchards 12
Time to irrigate orchards 27
Number of irrigations per season 27
Duty of water in orchard irrigation 28
Evaporation losses from orchard soils 31
Loss of water due to percolation 35
Removal of waste water 37
Influence exerted by time of irrigation 38
Winter irrigation of orchards 40

FARMERS' BULLETIN NO. 883.—GRAINS FOR THE UTAH DRY LANDS.

Dry land sections of Utah 3
Dry farming in Utah 6
Dry-farm crops 7
Growing the grain crops 7
Grain crops and varieties 14

FARMERS' BULLETIN NO. 884.—SAVING VEGETABLE SEEDS FOR THE HOME AND MARKET GARDEN.

Present shortage of vegetable seeds 3
How the supply may be increased 3
Plants which bear seed the year they are planted (annuals) 4
Plants which require a winter rest before producing seed (biennials) 9
Labeling, fumigating, and storing vegetable seeds 15

FARMERS' BULLETIN NO. 885.—WHEAT GROWING IN THE SOUTHEASTERN STATES.

Increase in the wheat area 3
Cost of production and yields per acre 3
Soils adapted to wheat 4
Fertilizers 4
Rotations 5
Preparation of the seed bed 6
Preparing and sowing the seed 6
Varieties 8
Pests of the wheat crop 8
Uses of the wheat crop 12
Harvesting the crop 13

FARMERS' BULLETIN NO. 886.—HARVESTING SOY-BEAN SEED.

The soy bean as a seed crop 3
Time of harvesting 3
Methods of harvesting 4
Methods of curing and handling 5
Thrashing 6
Special bean harvesters 7
Soy-bean straw 7
Storage of seed 8

FARMERS' BULLETIN NO. 887.—RASPBERRY CULTURE. Page.
Types of raspberries 3
Extent and distribution of raspberry growing 4
Location of plantation 5
Site of a plantation 6
Preparing the land 7
Planting 7
Moisture supply in the soil 14
Intercropping 15
Tillage 15
Maintenance of fertility 16
Systems of training and pruning 17
Winter protection 30
Duration of a plantation 32
Harvesting 33
Yields 34
Diseases and insects 35
Propagation 35
Varieties 36
Uses 42

FARMERS' BULLETIN NO. 888.—ADVICE TO FOREST PLANTERS IN THE PLAINS REGION.
Objects of planting 3
The region 4
Choice of species 4
Species recommended for planting 5
Mixed plantations 13
Ornamental planting 14
Details of planting 15
Methods of planting 16
Time of planting 17
Spacing 17
Cultivation 19
Thinning 20
Pruning 21
Protection 22
Where to secure trees and seed 24
Don'ts for tree planters 24

FARMERS' BULLETIN NO. 889.—BACK-YARD POULTRY KEEPING.
Advantages of home poultry 3
Overcoming objections to keeping poultry in the city 4
Kind of fowls to keep 4
Size of flock 5
Procuring stock 5
Housing 7
The yard 13
Feeding 15
Lice and mites 19
Hatching and raising chicks 20
Culling the hens 20
Preserving the eggs 21
Practical pointers 22

FARMERS' BULLETIN NO. 890.—HOW INSECTS AFFECT THE PLANT, AND MEANS OF COMBATING THEM.
How cotton attracts insects 3
How insects may be controlled before planting 4
Pests that menace the stand of seedling cotton 4
Injuries which abort the growth 7
Injuries to the growing tip 9
Leaf injuries and defoliation 10
How insects reduce the yield 16
Injuries to the stalk and roots 22
Insects in decayed and dry bolls 24
The double rôle of ants 24
The parasites 25
Insect visitors of cotton 26
Summary of control measures 26

Farmers' Bulletin No. 891.—The Corn Root-aphis and Methods of Controlling It.

Page.

The corn root-aphis and its injury ... 3
Seasonal history and habits ... 5
Relation between ants and aphids ... 8
Past history ... 9
Methods of control ... 10

Farmers' Bulletin No. 892.—Spring Oat Production.

Importance of the oat crop ... 3
Soils adapted to the production of oats ... 4
Fertilizers and manures ... 5
Oats in the rotation ... 6
Preparation of the seed bed ... 9
Preparation of the seed ... 11
Treating the seed for smut ... 12
Sowing the seed for smut ... 12
Sowing the seed ... 12
Treatment after seeding ... 15
Harvesting the crop ... 17

Farmers' Bulletin No. 893.—Breeds of Dairy Cattle.

Factors to be considered in the selection of a breed ... 3
Origin and characteristics of the breeds ... 6
  Ayrshire ... 7
  Brown Swiss ... 12
  Guernsey ... 17
  Holstein-Friesian ... 23
  Jersey ... 29

Farmers' Bulletin No. 894.—Rye Growing in the Southeastern States.

Increase rye production ... 3
Rye as a supplement to wheat ... 3
When to raise rye instead of wheat ... 3
Varieties of rye ... 3
Uses of the rye crop ... 5
Production of the rye crop ... 6
Harvesting the crop ... 11
Pests ... 13

Farmers' Bulletin No. 895.—Growing Winter Wheat on the Great Plains.

Farming conditions on the Great Plains ... 3
Varieties of winter wheat ... 4
Rate of seeding ... 4
Date of seeding ... 5
Adaptation, relative value, and cultural methods ... 5
General considerations ... 11

Farmers' Bulletin No. 896.—House Rats and Mice.

Destructive habits ... 3
Protection of food and other stores ... 5
Destroying rats and mice ... 11
Organized efforts to destroy rats ... 20
Important repressive measures ... 22

Farmers' Bulletin No. 897.—Fleas and Their Control.

Life history and habits ... 3
Length of life of the adults ... 5
Abundance of fleas, with relation to season, climate, and other conditions ... 5
Fleas as pests in the household ... 6
Fleas injurious to poultry and domestic animals ... 7
The relation of fleas to bubonic plague ... 9
Means of repression ... 10
Treatment of fleabites ... 15

Farmers' Bulletin No. 898.—Standard Varieties of Chickens. II. The Mediterranean and Continental Classes.

Importance of egg production ... 3
Characteristics of the egg breeds ... 3

FARMERS, BULLETIN NO. 898.—STANDARD VARIETIES OF CHICKENS. II. THE MEDITERRANEAN AND CONTINENTAL CLASSES—Continued.

Page.
Breeds and varieties ____ 6
Leghorn ____ 6
Minorca ____ 15
White-faced Black Spanish ____ 19
Blue Andalusian ____ 20
Ancona ____ 22
Campine ____ 24

FARMERS' BULLETIN NO. 899.—SURFACE IRRIGATION FOR EASTERN FARMS.

Conditions adapted to surface irrigation ____ 4
Amount of water needed in furrow irrigation ____ 5
Obtaining a water supply ____ 7
Conveying the water to the land ____ 9
Detail of pumping plants ____ 11
Distributing the water ____ 18
Applying the water to crops ____ 27
Cost of irrigation ____ 33
Information needed in design of a plant ____ 35

FARMERS' BULLETIN NO. 900.—HOMEMADE FRUIT BUTTERS.

Homemade fruit products ____ 3
Necessary equipment ____ 3
Apple butter with cider ____ 3
Apple butter without cider ____ 5
Apple butter with grape juice ____ 5
Apple butter with lemons ____ 5
Pear butter ____ 6
Peach butter ____ 6
Peach butter made with dried and canned peaches ____ 6
Peach butter with lemon juice ____ 6
Plum butter ____ 6
Garfield butter ____ 7

INDEX.

	Farmers' Bulletin No.	Page.
Acid, carbolic, use in control of flea bites	897	15
Agrotis ypsilon. *See* Cutworms.		
Air lift, use in raising water for irrigation	899	13
Alabama—		
argillacea, description and injury to cotton	890	10
wheat growing, and in other Southeastern States	885	1–14
Ambrosia trifida, injury to cotton, note	890	23
Ancona chickens, varieties, description and characteristics	898	22–23
Andulasian chickens, blue, description and characteristics	898	20–22
Anise oil, use as repellant against corn root aphis	891	11
Ant—		
brown, relation to corn root aphis	891	8–9
cornfield, relations to corn root aphis	891	8–9
leaf-cutting, injuries to cotton, and control	890	13–14, 24–25
Anthonomus grandis. *See* Weevil, cotton-boll.		
Anthracnose—		
raspberry disease, note	887	35
rye, prevalence, description and control	894	14
Ants, cotton field	890	24–25
Antwerp raspberry, origin, description, and sectional suitability	887	38–39
Apantesis arge, injury to cotton, control	890	15–16
Aphis, cotton, description, injuries and control	890	7
gossypii. *See* Aphis, cotton.		
maidiradicis. *See* Corn root aphis.		
Apple butter, making at home, various recipes	900	3–5
Apples, storage for home use	879	22
Arbor vitae, Chinese, description, uses, and planting details	888	13, 19
Armadillidum vulgare, injury to cotton, control	890	7
Army worm—		
beet, injury to cotton, and control	890	15–16
fall, description, injury to cotton and control	890	8–9
Arsenic, rat poison, use and value	896	16–17
Asafetida, tincture, use as repellant against corn root aphis	891	11
Ash—		
green, description, uses, and planting details	888	11, 13, 19
mountain, value as ornamental for Plains region	888	14
Atta texana, injury to cotton, control	890	13–14, 24–25
Auger, post-hole, use and value in testing ground water in irrigated orchards	882	37
Ayrshire cattle, origin, characteristics, score cards, and record producers	893	7–12
BABCOCK, RAY F., JOHN H. MARTIN, and RALPH W. SMITH, bulletin on "Grains for western North and South Dakota"	878	1–22
Back yard, poultry keeping in	889	1–23
Baits—		
poison, preparation for rats, use and value of various kinds	896	15–18
rat	896	12
Barberry, value as ornamental for Plains region	888	14–15
Barium carbonate, rat poison, use and value	896	16

	Farmers' Bulletin No.	Page.
Barley, growing—		
North Dakota and Montana	878	18–19
Utah dry lands	883	19–20
Barrel trap, rat, description	896	14
Basswood, value as ornamental for Plains region	888	14
Beans—		
navy, acre value in food	877	4, 8
seed saving	884	5
soy. *See* Soy beans.		
storage for home use	879	15
string, fermenting in dry salt or brine, and use	881	9, 10, 13
BEATTIE, JAMES H., bulletin on "Home storage of vegetables"	879	1–22
Beef, production from acre of staple crops	877	5, 10
Bees, aid in fertilization of cotton plants, note	890	26
Beetle, cotton stalk-borer, injuries, note	890	23
Beetles—		
blister, injuries to cotton, and aid in destruction of other insects	890	21–22
leaf, occurrence on cotton, note	890	22
May—		
control by winter plowing and poisoned bait	890	4, 6
injuries to cotton and control methods	890	6
soldier, injuries to cotton and aid in destruction of other insects	890	21–22
Beets—		
seed saving	884	13, 14
storage for home use	879	15–16
Berries, growing, canning, preserving, etc., Agriculture Department publications, list	887	45
Berry, buffalo, description, use, and planting details	888	9, 19
BISHOPP, F. C., bulletin on "Fleas and their control"	897	1–16
Black—		
pearl raspberry. *See* Pearl raspberry.		
Spanish chickens, white-faced, description and characteristics	898	19–20
Bollworm, injuries to various crops, description and control	890	18
Bones, value as hen feed, and feeding method	889	18
BORDEN, A. D., and E. R. SASSCER, bulletin on "Fumigation of ornamental greenhouse plants with hydrocyanic-acid gas"	880	1–20
Boxelder, description, uses, and planting details	888	11, 19
Brachystola magna. *See* Grasshoppers.		
BRACKEN, AARON F., and JENKIN W. JONES, bulletin on "Grains for the Utah dry lands"	883	1–22
Breeds—		
chickens, Mediterranean and continental	898	1–26
dairy cattle, selection, description, characteristics, etc	893	1–35
Brown Swiss, dairy cattle, description, characteristics, score cards, and records	893	12–16
Bubonic plague, introduction by fleas, through rats and mice	897	9
Buckwheat, acre value in food	877	4, 9
Bugs, cotton, various names, injuries and control	890	21
Buildings, rat-proof, directions for construction	896	5–8
Bulls—		
dairy breeds, progeny records	893	12, 16, 22, 28, 34
prepotency, importance in dairy herd	893	5
Butter—		
color, addition to cream, directions	876	13, 22
farm production, percentage	876	3
leaky, cause and objections	876	12
making equipment, on farm	876	20–21
making on the farm	876	1–23
packing, printing, and wrapping	876	17–18, 23
washing, salting, working, and packing	876	14–18, 22–23

	Farmers' Bulletin No.	Page.
Butter fat—		
highest producers, different dairy cattle breeds	893	11, 16, 21, 28, 33
yield per acre	877	4, 6
Cabbage, fermented. *See* Sauerkraut.		
Cabbages, storage for home use	879	16–17
Campine chickens, varieties, descriptions and characteristics	989	24–25
Camps, rat control, suggestions	896	8, 11
Cane blight, raspberry disease, note	887	35
Cane borer, raspberry insect, note	887	35
Canning, raspberries, methods	887	43
Caradrina exigua. *See* Army worm, beets.		
Caragana arborescens, description, use and planting details	888	9, 19
Carbon disulphid, fumigation of garden seeds	884	14–16
Carrots—		
seed saving	884	13, 14
storage for home use	879	17
Cat flea—		
control measures	897	10–11
description and occurrence	897	8–8
Catalpa, value as ornamental for Plains region	888	14
Caterpillar—		
salt-marsh, injuries to cotton, and control	890	15
spp., injuries to cotton and control	890	15–16
Cats, value in control of rats and mice	896	18
Cattle, dairy breeds	893	1–35
Cedar, red, description, uses, mixtures, and planting details	888	12, 13, 19
Celery—		
seed saving	884	11
storage for home use	879	18–20
Cellars, storage, types, in dwellings and outdoors	879	4–13
Cereals, production, Northern Great Plains, publication list	878	22
Chalcodermus aenus, description and injury to cotton	890	9
Chauliognathus, spp., injury to cotton, note	890	21–22
Cheese, yield per acre	877	4, 6, 10
Chestnut, horse, value as ornamental for Plains region	888	14
Chicken flea—		
control measures	897	14–15
description, occurrence on poultry	897	7–8
Chickens—		
Andalusian, description, weights, etc	898	20–22
continental class, characteristics	898	6, 24–25
egg breeds, characteristics	898	3–5
leghorn, varieties, description, weights, etc	898	6–15
Mediterranean class, characteristics	898	6–23
Minorca varieties, description, weights, etc	898	15–19
raising in back yard	889	1–23
Spanish, description	898	19–20
standard varieties II. The Mediterranean and continental	898	1–26
Chicks, hatching and raising, practicability, time, and method	889	20
CHILCOTT, E. C., and JOHN S. COLE, bulletin on "Growing winter wheat on the Great Plains"	895	1–12
Chloridea obsoleta. *See* Bollworm.		
Churning—		
difficult, causes and remedies	876	18–19
process, details and summary	876	10–14, 22–23
process, temperature of cream, etc	876	10–14
CLOSE, C. P., bulletin on "Homemade fruit butters"	900	1–7
Coal-tar products, use in control of hen mites	889	19–20
Cock, chicken, chart giving names of various sections	898	2
COLE JOHN S., and E. C. CHILCOTT, bulletin on "Growing winter wheat on the Great Plains"	895	1–12
Collards, seed saving	884	10
Color, butter, addition to cream, directions	876	13, 22

	Farmers' Bulletin No.	Page.
Colorado—		
forest trees, species adaptable, and planting details	888	5–15, 19
winter wheat growing	895	8
Columbian raspberry, origin, description, and sectional suitability	887	41
Conifers, adaptation to Plains region, uses and planting details	888	9–10, 12–13, 16, 19
Conservation, vegetables, by fermentation and salting	881	1–15
Cooking, vegetables, fermented or salted, for table use	881	12–15
COOPER, MORTON O., and W. J. SPILLMAN, Bulletin on Human food from an acre of staple farm products"	877	1–11
Cooperation, community—		
in breeding dairy cattle, importance	893	4
value in control of corn-root aphis	891	11–12
Copperas, spray for weed control in oat field, formula, rate, and method	892	16–17
Corn—		
acre value in food	877	4, 6
brining and salting, and preparation for table	881	10, 11, 13–14
crib, rat-proofing, directions	896	7, 9
growing in Utah dry lands, experiments	883	20–21
root aphis—		
control methods	891	1–12
relation to brown ant	891	8–9
repellants, selection and use, value	891	11
See also Root aphis, corn.		
sweet, seed saving	884	5–6
Cornfield ant, relation to corn-root aphis	891	8–9
Cotton—		
attractiveness for insects	890	3–4
louse. *See* Aphis, cotton.		
plant, insects affecting and means of combating them	890	1–28
plants, dried, disposal for insect control	890	24, 27
rotations, use of rye crop	894	7
stainer, description, habits, injuries, and control	890	20
Cotton-insect control, method, summary	890	26–27
Cottonwood—		
"cottonless," from staminate trees, securing plants	888	7, 15
species, description, associates, uses and planting details	888	6–7, 13, 19
Cover crop—		
rye, value in South	894	5–6
use and value of oats	892	9
Cowpeas, acre value in food	877	4, 9
Cows—		
Ayrshire, description, characteristics, and records	893	7–12
Brown Swiss, description, characteristics, and records	893	12–16
Guernsey, description, characteristics, score cards, and records	893	17–23
Holstein, origin, description, characteristics, and records	893	23–29
Jerseys, description, characteristics, and records	893	29–34
Crayfish, injury to cotton and control	890	7
Cream—		
churning too warm, injury to butter, loss	876	10–12
cooling, details	876	6–7
quality and preparation for butter making	876	3–9
ripening for churning	876	7–8, 22
separation methods	876	3–6
Creosote, coal-tar, saponified, use and value in control of fleas	897	10
Cricket, snowy-tree, injury to cotton, habits and control	890	23
Crop rotation—		
place of oats in mixture with other crops	892	6–8
value in wireworm and corn-root aphis control	892	22
Ctenocephalus—		
canis. *See* Dog fleas.		
felis. *See* Cat fleas.		

	Farmers' Bulletin No.	Page.
Cucumbers, seed saving	884	6
Cultivation, use in control of corn root-aphis, methods	891	10–11
Cumberland respberry, origin, description, and sectional suitability	887	41
Cuthbert raspberry, origin, description, and sectional suitability	887	39
Cutting—		
oats, time and methods	892	17–18
tree, directions for making and rooting	888	15
Cutworm—		
cotton-boll, description, injuries, and control	890	19–20
injury to cotton, control by poisoned bait	890	5–6
Cyanid, sodium, use as spray in control of leaf-cutting ant, formula, and use warning	890	13–14
Dairy—		
cattle breeds, selection, description, characteristics, etc	893	1–35
equipment for farm butter making, and house	876	20–22
farming, publications list	893	35
house plan	876	21–22
products, yield of 1 acre	877	4, 6, 9–10
utensils, cleaning, importance, and suggestions	876	5–6
DARROW, GEORGE M., bulletin on "Raspberry culture"	887	1–45
DAVIS, H. P., bulletin on "Breeds of dairy cattle"	893	1–35
DAVIS, JOHN J., bulletin on "The corn root-aphis and methods of controlling it"	891	1–12
Dewberries—		
acreage in United States, 1909, by States	887	4–5
Logan, acreage, 1909, by States	887	4–5
Dickinson experiment station, location and farming conditions	878	3–6
Diseases, raspberry, list, control information, and source	887	35
Disking, use and value in control of southern grassworm	890	9, 26
Disulphid, carbon, use in crayfish, control and use method	890	7
Ditches, water-conveyance discharges for different grades	899	10
Dog flea—		
control measures	897	10–11
description and occurrence	897	8–9
Dogs, value in control of rats and mice	896	18
Drainage—		
value in crayfish control	890	7
waste-water removal in irrigated orchards, methods, drains, etc	882	37–38
Dry farming—		
Dakotas and Montana, conditions, etc	878	3–21
grain growing	883	1–22
Utah, development and practices	883	6–14
winter wheat, growing in Great Plains	895	1–12
Dry lands, grains for Utah	883	1–22
Drying, raspberries, on bushes, picking methods	887	34
Dust boxes, value in control of lice on hens	889	19
Dwelling, rat-proof, requirements and suggestions	896	5–6
Dysdercus suturellus, description, habits, and injury to cotton	890	20
Echidnophaga gallinacens. *See* Chicken flea.		
Egg breeds, chickens, characteristics	898	3–5
Eggplant, seed saving	884	7
Eggs—		
preserving, time and method	889	21–22
yield per acre	877	4, 6
Eleagnus angustifolia, description, uses, associates and planting details	888	8, 13, 19
Elm, white, description, associates, uses, and planting details	888	6, 13, 19

	Farmers' Bulletin No.	Page.
Emmer, growing—		
North and South Dakota	878	16
Utah dry lands, details	883	18
Endive, seed saving	884	9
Engines, pumping plants, description and cost	899	14–15
Epicauta vittata. *See* Beetles, blister.		
Ergot, rye, nature and control	894	14
Erskine raspberry, origin, description, and value	887	42
Estigmene acraea, injury to cotton, control	890	15
Evaporation, orchard soils, water losses	882	31–35
Experiment farms, western North and South Dakota, location and conditions	878	3–6
Fallow, summer, Utah dry lands	883	10
Farm—		
buildings, rat-proofing, directions	896	7
butter making	876	1–23
products, acre value in human food	877	11
Farmer raspberry, origin, description, and sectional suitability	887	41
Farming, Great Plains, conditions	895	3–4, 11–12
Farms, eastern, surface irrigation	899	1–36
Feeding, hens, city back yard, methods and feed	889	15–19
Fence and battue, method of trapping rats	896	15
Fermentation, vegetables, with dry salting and in brine	881	5–11
Ferrets, value in control of rats and mice	896	18
Fertility, maintenance—		
by manure or fertilizer for control of corn root-aphis	891	11
on raspberry plantations, use of fertilizers, etc	887	16–17
Fertilizers—		
oats, value, kinds, and formulas	892	5–6
rye, requirements	894	9
wheat, use and application in Southeastern States	885	4–5
Fir—		
Douglas, value as ornamental for Plains region	888	15
white, value as ornamental for Plains region	888	15
Flax, growing in western North Dakota, details	878	20–21
Flea—		
bites, symptoms and control method	897	15
poultry, description, habits and control	897	7–8
Fleas—		
breeding, relation of season, climate, and other conditions	897	5–6
control methods	897	10–15
destruction in immature stage, method	897	11–13
history, habits, and control	897	1–16
Fluorid, sodium, use in control of hen lice	889	19
Fly paper, use in control of fleas	897	13
Food—		
production from an acre of staple farm products	877	11
protection from rats and mice	896	5–11
vegetable, preservation by fermentation and salting	881	1–15
Foodstuffs, buildings for storing, rat-proof construction needed	896	7–8
Forest plantations—		
cultivation, thinning, pruning, and protection	888	19–23
mixed species recommended, Great Plains	888	13–15
planting in Plains region, advice	888	1–23
protection methods	888	22–23
species and mixtures for Plains region	888	5–15
trees, species recommended for Plains region, northern and southern	888	5–18
Formaldehyde, use—		
against grain smuts	885	10–11
on grain for smuts	883	11–12
FORTIER, SAMUEL, bulletin on "Irrigation of orchards"	882	1–10

	Farmers' Bulletin No.	Page.
Fruit—		
butters—		
homemade	900	7
preparation, equipment	900	3
growing, irrigation of orchards	882	1–40
Fumigation—		
garden seeds	844	14–16
greenhouse—		
experiments and results	880	13–18
plants, with hydrocyanic-acid gas	880	20
precautions and guide	880	11–18
requirements	880	4–9
hydrocyanic-acid gas, cost for greenhouse plants	880	11
rats and mice	896	18–19
seed, directions	884	15–16
stored grains, insect control	885	9–10
use and value in flea control	897	11–13
Furrow irrigation, Eastern States, directions	899	29–32
Garbage, protection from rats	896	10–11
Garden seeds, saving	884	1–16
Gardens, home and market, seed saving for	884	1–16
Garfield butter, recipe	900	7
Garlic, wild, control in rye	894	13
Georgia, wheat growing, and in other Southeastern States	885	1–14
Golden Evergreen raspberry, hybridization studies, origin, description and value	887	42
Gophers, poisoning, suggestions	888	23
Grain—		
crops, dry farming	883	1–22
growing, seeding, harvesting, etc	878	6–10, 15, 16, 18, 19, 21
seed, cleaning, grading, and treatment for smut	883	11–12
stored, insect pests, control	885	9–10
value as hen feed, feeding method	889	17
Grains—		
Dakotas	878	1–22
seeding—		
in dry land farming	883	16–17, 18, 19, 20
rates	878	15, 16, 18, 19, 21
small—		
growing, publications list	894	15
varieties recommended for Dakota and Montana	878	21
Utah dry lands	883	1–22
Grass, value as hen feed	889	18
Grasshoppers, injuries to cotton, description, and control	890	7, 9, 10–12
Grassworm, southern, description, injury to cotton, and control	890	8–9
Great plains—		
growing winter wheat	895	12
region, forest planters, advice to	888	1–23
Gregg raspberry, origin, description, and sectional suitability	887	41
Greenhouse—		
fumigation with hydrocyanic-acid gas	880	1–29
infestation with insects, manner	880	10–11
Greens, fermentation and dry salting, directions, and table use	881	9, 10, 11, 13
Grits, value as hen feed	889	18
Guernsey cattle, description, characteristics, origin, records, and score cards	893	17–23
Hackberry, description, associates, uses, and planting details	888	5, 13, 19
Hailsham raspberry, origin, introduction, and value	887	42
Harvesters, bean, types	886	7

	Farmers' Bulletin No.	Page.
Harvesting—		
oats, irrigation States, cutting, shocking, stacking, thrashing	892	17–22
raspberries, picking and handling methods	887	33–34
rye crop, cutting, shocking, thrashing, and yield	894	11–13
soy-bean seed	886	1–8
wheat in Utah dry regions	883	13–14
Hen houses for back yards, description, material required, and cost	889	7–13
Hens—		
broody, control, time required and method	889	13
culling and replacing	889	21
feeding in city backyards, methods and feed	889	15–19
home keeping, advantages	889	3–4
keeping—		
in back yards, suggestions, summary	889	22
in cities, overcoming objections	889	4
kinds for back-yard keeping, discussion and studies	889	4–5
Hessian fly—		
control in rye crop	894	13
wheat pest, control	885	8–9
Himalayan Golden raspberry, hybridization, studies, origin, description, and value	877	42
Hogs, fleas, and control methods	897	11
Holstein Friesian cattle, origin, description, characteristics, score cards, and records	893	23–29
Home—		
poultry raising, in back yard	889	1–23
storage of vegetables	879	1–22
Homemade fruit butters	900	1–7
Honey locust, description, associates, uses, and planting details	888	5, 13, 19
Hoosier raspberry, origin, description, and sectional suitability	887	41
Hose—		
garden, homemade, lengths and joints	899	28–29
use in surface irrigation	899	28–29
House mice. *See* Mice, house.		
House rats. *See* Rats, house.		
Houses, infestation with fleas, sources and control	897	6–7, 10–11, 13
Hybrid raspberries, experiments and studies	887	42
Hydrants, irrigation, description	882	8, 9
Hydrocyanic-acid gas—		
fumigation of greenhouse plants	880	1–20
generators	880	3–4
poisonous nature	880	3
use and value in control of fleas, use direction and warning	897	12
use in control of rats and mice	896	19
Hyperchirisio, injury to cotton	890	15–16
Idaho, drying raspberries on bushes, picking method	887	34
Iodine, use in control of flea bites, use, warning	897	15
Insects—		
cotton, control before planting, method	890	4
effect on—		
cotton plants, and means of combating them	890	1–28
cotton yield, list	890	16–22
greenhouse, control by fumigation with hydrocyanic-acid gas, experiments	880	13–18
injuries to cotton—		
and control method	890	4–26
stalks and roots, list	890	22–24
injurious to cereal and forage crops, Agricultural Department publications, list	891	12

	Farmers' Bulletin No.	Page.
Insects—Continued.		
occurrence in decayed and dry cotton bolls, list and control	890	24
raspberry, list, control information, and source	887	35
Intercropping, value in first-year raspberry plantations	887	15
Irrigation		
acreage requirements, sizes of pumps and engines	899	16
designing of plant for farm, information needed	899	35
eastern farms, cost	899	33–35
humid regions, methods	899	3–4
methods	899	3–4
orchards	882	1–40
orchards, times and frequency, influence on peaches, experiments	882	38–39
publications, list	899	35–36
surface for eastern farms	899	1–36
value in raspberry growing	887	15
water requirement of oats, and use in dry-land States	892	17
winter, of orchards	882	40
Jack pine, description, uses, associates, and planting details	888	9–10, 13, 19
Jam, making from raspberries, methods	887	43–44
Jersey cattle, origin, description, characteristics, score cards, and records	893	29–34
Jones, Jenkin W., and Aaron F. Bracken, bulletin on "Grains for the Utah dry lands"	883	1–22
Kale, seed saving	884	10
Kansas—		
forest trees, species adaptable, and planting details	888	5–15, 19
raspberry, origin, description, and sectional suitability	887	41
winter wheat, growing	895	9
Kerosene—		
emulsion, use and value in control of fleas, use method	897	10, 11
use as repellant against corn root-aphis	891	11
use in control of hen mites	889	19–20
Kohl-rabi, seed saving	884	10
Labeling, seeds, directions	884	14–15
Land, clearing and grading, for citrus-fruit orchards, methods and cost per acre	882	7–9
Lang, H. L., and L. A. Round, bulletin on "Preservation of vegetables by fermentation and salting"	881	1–15
Lantz, David E., bulletin on "House rats and mice"	896	1–24
Laphygma frugiperda. *See* Army worm, fall.		
Lasius niger—		
relation to corn root-aphis	891	8–9
See also Ant, cornfield.		
Lead arsenate, use in control of cotton insects, methods and outfit	890	8–9, 10, 15–16, 18, 19, 27
Leafhoppers, injury to cotton, note	890	23–24
Leafworm, cotton, description, injuries and control	890	10
Leghorn chickens, varieties, descriptions, and characteristics	898	6–15
Leighty, Clyde E.—		
bulletin on "Rye growing in the Southeastern States"	894	1–16
bulletin on "Wheat growing in the Southeastern States"	885	1–14
Lemon oil, use as repellant against corn root-aphis	891	11
Lettuce, seed saving	884	7–8
Lice, injuries to hens, and control	889	19
Limewater, use in preserving eggs	889	22
Live stock, products, from acre of staple crops	877	5–6, 7–9
Locust, black, description, uses, mixtures, and planting details	888	12, 13, 19

	Farmers' Bulletin No.	Page.
Logan dewberries, acreage, 1909, by States	887	4
Loganberry—		
acreage, 1909, by States	887	4
origin, note	887	4
Loxostege sticticalis. *See* Webworm, beet.		
Machinery, harvesting, for soy-bean seed	886	4–5
Manures, oats, value for oats, kind and application	892	5–6
Maple, silver, value as ornamental for Plains region	888	14
MARTIN, JOHN H., RAY F. BABCOCK, and RALPH W. SMITH, bulletin on "Grains for western North and South Dakota"	878	1–22
Mash, dry, value as hen feed, and feeding method	889	17–18
May beetles. *See* Beetles, May.		
Melanoplus differentialis. *See* Grasshoppers.		
Merchandise, protection from rats and mice	896	9
Mice—		
control, important measures, summary	896	22–23
destruction, methods, traps, poisons, and other means	896	11–20
fleas, agency in spread of bubonic plague	897	9
house, habits and control	896	1–24
Milk—		
highest producers, of different dairy cattle breeds	893	11, 16, 21, 27, 33
market demands	893	3–4
production—		
dairy breeds, composition and amount	893	10–11, 15–16, 21, 27–28, 33
from acre of staple crops	877	5, 10
Millet, growing in North Dakota and South Dakota	878	21
Minorca chickens, varieties, descriptions, and characteristics	898	15–19
Mississippi, wheat growing, and in other Southeastern States	885	1–14
Mites, injuries to hens, and control	889	19–20
Monocrepidius vespertinus. *See* Wireworms.		
Montana—		
eastern—		
grains adapted to, (with western Dakota)	878	22
topography, climate, and farming conditions	878	3–6
forest tree, species adapted, and planting details	888	5–10, 19
winter wheat growing	895	6–7
MORSE, W. J., bulletin on "Harvesting soy-bean seed"	886	1–8
Moth—		
io, injury to cotton, and control	890	15–16
pine tip, injury to Western yellow pine	888	10
tiger, injuries to cotton, and control	890	15–16
Mus musculus, distribution and destructivenss	896	3–4
Muskmelons, seed saving	884	6
Mustard, seed saving	884	8
Naphthalene, flaked, use and value in flea control	897	11–12, 13–14
Nebraska—		
forest trees, species adaptable, and planting details	888	5–10, 19
winter wheat growing	895	7–8
New Mexico, winter wheat growing	895	10–11
Newell experiment station, location and farming conditions	878	3–6
North Carolina, wheat growing, and in other Southeastern States	885	1–14
North Dakota—		
forest trees, species, adaptable, and planting details	888	5–10, 19
western—		
grains adapted to	878	22
topography, climate, and farming conditions	878	3–6
Nurse crop, use and value of oats	892	8–9
Nursery stock, raspberries, selection and handling	887	9–10
Nuts, planting for seed	888	16

	Farmers' Bulletin No.	Page.
Oak, bur, value as ornamental for Plains region	888	14
Oats—		
acre value in food	877	4, 8
economic importance, distribution and production	892	3–4
growing—		
in Utah dry lands	885	18–19
in western North Dakota and Montana	878	17–18
production, Agriculture Department publications, list	892	23
spring, production	892	1–23
treatment after seeding	892	15–17
Oecanthus niveus, injury to cotton, habits and control	890	23
Ohio raspberry, origin, description, and sectional suitability	887	41
Oil—		
anise, use as repellant against corn root-aphis	891	11
lemon, use as repellant against corn root-aphis	891	11
of tansy, use as repellant against corn root-aphis	891	11
sassafras, use as repellant against corn root-aphis	891	11
Ointment, blue, use in control of hen lice	889	19
Oklahoma—		
forest trees, species adaptable, and planting details	888	5–15, 19
winter wheat growing	895	9–10
Okra, seed saving	884	7
Older raspberry, origin, description, and sectional suitability	887	41
Olive, Russian, description, uses, associates, and planting details	888	8, 13, 19
Onion, wild, control in rye	894	13
Onions—		
seed saving	884	11–12
storage for home use	879	20
Orchard trees, setting plans	882	10–11
Orchards—		
irrigated, location of rows and trees	882	9–11
irrigation	882	1–40
sites, soils, and exposures, selection	882	3–4
Ornamentals for Great Plains, species adapted, descriptions	888	14–15
Papaipema nitela, injury to cotton, note	890	23
Parsnips—		
seed saving	884	13
storage for home use	879	20
Pea tree, Siberian, description, use, and planting details	888	9, 19
Peach butter, making, directions	900	6
Peanuts, acre value in food	877	4, 8
Pear butter, making, directions	900	5
Pear raspberry, origin, description, and sectional suitability	887	41
Peas—		
brining and salting, and preparation for table	881	10, 11, 14–15
seed saving	884	5
storage for home use	879	15
Peppers, seed saving	884	7
Peridroma margaritosa. See Cutworms.		
Perishables, storage for home use	879	1–22
Pests—		
rye, including weeds, insects and diseases, control	894	13–14
wheat crop, control measures	885	8–10
Petroleum, crude, use in control of hen mites	889	19–20
Phosphorus, rat poison, use and value	896	17
Phyllophaga cribosa. See Beetles, May.		
PIERCE, W. DWIGHT, bulletin on "How insects affect the cotton plant and means of combating them"	890	1–28
Pillbugs, injury to cotton, and control	890	7
Pine—		
jack, description, uses, associates, and planting details	888	9–10, 13, 19
tip moth, injury to Western yellow pine	888	10
yellow, description, uses, associates, and planting details	888	10, 13, 19

	Farmers' Bulletin No.	Page.
Pipe—		
concrete reinforced, use in irrigation work	899	24–27
portable, use in surface irrigation	899	27–29
surface irrigation, cost, table	899	34
systems, for distribution of irrigation water	899	18–27
Pipes—		
sewer, selection, testing, tamping, and cementing	899	19–20, 26
terra-cotta, use in irrigation systems	899	18–24
Pits, storage, for vegetables	879	13–14
Plains region, forest planters, advice to	888	23
Plant-bugs. injuries to crops, and control	890	21
Plantations, forest, cultivation, thinning, pruning, and protection	888	19–23
Planting—		
raspberries, time, methods, distance, etc	887	7–14
tree, methods, slit and deep-hole, directions	888	16–17
Plants, raspberry—		
propagation methods	887	36
selection, setting, treatment at setting, and cultivation methods	887	9–14
Plowing, winter, for insect control in cotton	890	4, 6, 7, 9, 12, 26
Plum butter, making, directions	900	6–7
Plunger pump, types, description, and use in irrigation	899	13
Poison—		
bait—		
formula, and use method	890	5–6
preparation for rats and mice	896	15–18
use against rodents in forest plantations	888	23
poultry house, for rats and mice	896	17–18
use in control of cotton insects, formula, etc	890	5–6, 7, 9, 26
Poisons—		
control of rats and mice	896	15–18
rat, recommendations, and caution	896	15–18
Pork, production from acre of staple crops	877	5, 10
Posts, trees adapted to Plains region	888	6, 8, 10, 11, 12, 13, 19
Potato, acre value in food	877	4, 7
Potatoes—		
seed saving	884	12
storage for home use	879	20
Poultry—		
Agriculture Department, publications list	899	23
house, back yard, construction, suggestions	889	7–13
infestation and injury from fleas	897	7–9
keeping, back-yard	889	1–23
publications, list	898	26
yards, protection by pit traps	896	15
yield per acre	877	4, 6
Prodenia ornithogalli. *See* Cutworm, cotton-boil.		
Propagation, raspberry plants, methods	887	35–36
Pruning—		
forest trees, and care of wounds	888	21–22
raspberry—		
for production of late fruit, method	887	29
systems	887	17–29
Publications—		
Agriculture Department—		
growing and uses of berries, list	887	45
oat production, list	892	23
poultry	889	23
cereal production, Northern Great Plains, list	878	22
dairy farming, list	893	35
insects injurious to cereal and forage crops, list	891	12
irrigation, list	899	35–36
poultry and eggs, list	898	26
small grains, growing, list	894	15

	Farmers' Bulletin No.	Page.
Pulex irritans, description and occurrence	897	6–7
Pumping plants, farm irrigation, details	899	11–17
Pumpkins, storage for home use	879	21
Pumps, centrifugal, types, description and use in irrigation	899	11–13
Rabbits, poisoning, suggestions	888	23
Radishes, seed saving	884	8–9, 14
Ram, hydraulic, use in lifting water supply	899	8
Ranere raspberry, origin, description, and sectional suitability	887	40, 42
Raspberries—		
acreage in United States, 1909, by States	887	4–5
growing, types, and methods	887	1–45
red, production of late fruit by pruning	887	29
uses, production by States, and canning methods	887	42
varieties, descriptions, and comparisons	887	3
varieties, origin, description, and sectional suitability	887	36–42
winter protection, methods, and cost	887	30–31
yield per acre	887	14, 34–35
Raspberry plantations—		
distribution, location, and land preparation	887	5–7
years of duration and profitableness	887	32–33
Rat, brown, introduction, habits, fecundity, and destructiveness	896	3–4
Rat-proofing buildings, suggestions	896	6–7
Rats—		
control—		
by fumigation, directions	896	18–19
important measures, summary	896	22–23
organized efforts, community, State, and National	896	20–22
destruction methods, traps, poisons, and other means	896	11–20
destructiveness, statements	896	3–4
enemies, natural, birds of prey and mammals	896	20
fleas, agency in spread of bubonic plague	897	9
house, habits and control	896	1–24
Ratius norvegicus, distribution and destructiveness	896	3–4
Rattus—		
ratius rattus, note	896	3
rattus alexandrinus, note	896	3
Red Spider. *See* Spider, red.		
Repellants, use against fleas, kind and use, method	897	13–14
Rice, acre value in food	877	4, 7
Rust, rye, losses from	894	14
Root-aphis, corn—		
control methods	891	1–12
description, distribution, and harmfulness to plants	891	3–5
history, destructiveness and control methods	891	9–12
injury and habits	891	4–8
injury to cotton, description and control	890	22
relatoin to cornfield ants	891	8–9
Rotation, use in control of corn-aphis	891	10
Rotations, rye growing	894	6–8
ROUND, L. A., and H. L. LANG, bulletin on "Preservation of vegetables by fermentation and salting"	881	1–15
Rye—		
acre value in food	877	4, 7
crops, uses, food, stock feed, cover crop, pasture, and silage	894	5–6
diseases, description and control	894	14
fertilizers, requirements, formulas, etc	894	9
growing—		
in Southeastern States	894	1–16
in western North and South Dakota	878	15–16
harvesting, shocking, thrashing, and yield	894	11–13

	Farmers' Bulletin No.	Page.
Rye—Continued.		
insect enemies, control	894	13
seeding time, method and rate	894	10–17
value for feed and grazing	894	5, 6
varieties	894	5
volunteer, objections in wheat fields	894	7–8
yield, Southern States	894	12–13
Salsify, storage for home use	879	22
Salt, use and value in control of fleas	897	12–13, 14
Salting, vegetables without fermenting	881	11
Sassafras oil, use as repellant against corn root-aphis	891	11
SASSCER, E. R., and A. D. BORDEN, bulletin on "Fumigation of ornamental greenhouse plants with hydrocyanic-acid gas."	880	1–20
Sauerkraut, directions for making	881	8–9
Score cards, dairy cattle breeds	893	6, 9–10, 14–15, 19–20, 25–27, 31–33
Seed—		
grain, cleaning, grading, and treatment for smut	883	11–12
oats, preparation, and treatment for smut prevention	892	11–12
rye, cleaning and testing	894	10
soy-bean, storage	886	8
wheat, treatment for smut	885	10–11
Seed bed—		
preparation—		
for grains in dry lands	883	7–9
for oats and seeding time, method, etc	892	9–11
rye, preparation	894	8–9
Seeding—		
grains in dry-land farming	893	16–17, 18, 19, 20
winter wheat in Great Plains, rate, date, etc	895	4–5
Seeds—		
garden, fumigation, labeling and storing	844	14–16
vegetable—		
fumigating, labeling, and storing	884	14–16
saving for home and market garden	884	1–16
shortage, causes and suggestions	884	3–4
Separator, cream, use and care of	876	4–6, 20, 22
Silage, rye, value as feed	894	6
SLOCUM, ROB R.—		
bulletin on "Back-yard poultry keeping"	889	1–23
bulletin on "Standard varieties of chickens. II. The Mediterranean and continental classes"	898	1–26
SMITH, RALPH W., RAY F. BABCOCK, and JOHN H. MARTIN, bulletin on "Grains for wetsern North and South Dakota"	878	1–22
SMITH, SEWARD D., bulletin on "Advice to forest planters in the Plains region"	888	1–23
Smuts—		
grain, treatment	883	11–13
wheat, treatment	885	10–11
Soil—		
moisture requirements for raspberries	887	14–15
mulches, effect in checking evaporation	882	33–35
Soils—		
adaptability for oats	892	4–5
adaptation—		
to certain forest trees	888	19
to rye	894	6
orchard, evaporation losses	882	31–35
wheat, requirements	885	4
South Carolina, wheat growing, and in other Southeastern States	885	1–14

	Farmers' Bulletin No.	Page.
South Dakota—		
western, grains adapted to	878	1–22
western, topograph, climate and farming conditions	878	2–6
winter wheat growing	895	7
Southeastern States, wheat growing	885	1–14
Southern States, rye growing, uses and value	894	1–16
Sowing, oats, time, rate, and method	892	12–15
Soy bean, shattering habits	886	3
Soy beans—		
acre value in food	877	4, 7
harvesting seed	886	1–8
storage of seed	886	8
Spider, red—		
injury to cotton, description, and control	890	12–13
raspberry insect, note	887	35
Spillman, W. J., and Morton O. Cooper, bulletin on "Human food from an acre of staple farm products"	877	1–11
Spinach, seed saving	884	9
Spraying—		
cotton insects	890	12–13, 20
oat fields, for weed control, time, method, and spray	892	16–17
petroleum or coal-tar products, use in control of hen mites, and method	889	20
Sprays, use and value in control of cotton red spider list, and formulas	890	12–13, 20
Spring oats, production	892	1–23
Spruce, blue, Colorado, value as ornamental for Plains region	888	15
Spur-blight, raspberry disease, note	887	35
Square-borer, cotton, injury and control	890	19
Squashes—		
seed saving	884	6
storage for home use	879	21
Squills, rat poison, use and value	896	17
Squirrels, fleas, agency in spread of bubonic plague	897	9
Stalk-borer, moth, injury to cotton, note	890	23
Stanley, F. W., bulletin on "Surface irrigation for eastern farms"	899	1–36
Starters—		
cream ripening, making, and use	876	9
preparation and use in farm butter making	876	9
Streams, source of irrigation, water supply	899	7–8
Sticktight flea. *See* Chicken flea.		
Storage—		
cellar or basement of dwelling, directions	879	6
garden seeds	844	16
types for home storage of perishables	879	4–14
vegetables, at home	879	1–22
Strainer, use in butter making	876	14, 21
Straw, soy-bean, feed value	886	7–8
Strychnine, rat poison, use and value	896	16
Subirrigation, requisites in humid regions	899	3–4
Sulphate—		
iron, use as spray for weed control in oat field, formula, rate and method	892	16–17
nicotine, spraying for control of cotton aphis	890	7
Sweet potato, acre value in food	877	4, 6
Sweet potatoes, storage for home use	879	20–21
Sycamore, value as ornamental for Plains region	888	14
Tansy, oil, use as repellant against corn root-aphis	891	11
Tennessee, wheat growing, and in other Southeastern States	885	1–14
Tetranychus telarius. *See* Spider, red.		
Texas, northern, forest trees, species adaptable and planting details	888	5–15, 19
Thermometer, use in butter making	876	8, 21, 22

	Farmers' Bulletin No.	Page.
Thrashing—		
oats, time and method	892	21–22
rye, practices	894	12
soy beans, practices	886	6–7
Tile, concrete reinforced, use in irrigation work	899	24–27
Tillage, raspberry, thoroughness and regularity, importance and methods	887	15–16
Timber, trees adapted to Plains region	888	5–6, 10, 19
Tomatoes, seed saving	884	6–7
TRACY, W. W., sr., bulletin on "Saving vegetable seeds for the home and market garden"	884	1–16
Trap, pit, construction use for rats and other small animals	896	15
Trapping, fleas, method	897	13, 14
Traps, rats and mice, description, types	896	11–15
Tree, planting, precautions, summary	888	23
Trees—		
forest—		
cultivation, thinning, pruning and protection	888	19–23
propagation for planting stock	888	15–16
spacing, and number to acre	888	17–19
planting, directions, details	888	15–19
Turbine pumps, description and use in irrigation	899	13
Turnips, seed saving	884	13
storage for home use	879	22
Uranotes melinus, injury to cotton, control	890	19
Utah—		
dry lands, grains for	883	1–22
dry sections, locations, soils and climate	883	3–6
Valves, irrigation, description and use	899	20–21
Vaseline, carbolated, use and value in control of sticktight fleas	897	14
Vegetable seeds. *See* seeds.		
Vegetables—		
fermented or salted, preparation for table use	881	12–15
fermenting in dry salt or brine, directions	881	5–11
preservation by fermentation and salting	881	1–15
storage—		
at home	879	1–22
for winter, economic considerations	879	3
value as hen feed	889	18
Virus, use in rat control discussion	896	19–20
WARBURTON, C. W., bulletin on "Spring oat production"	892	1–23
Water—		
application to crops, eastern farms, methods and cost	899	27–35
conveyance for irrigation on farms, methods	899	9–11
distribution in irrigation, Eastern States	899	18–27
requirements and value for hens	889	18–19
soil requirements for oats	892	4–5
supplies for orchards, irrigation districts	882	4–7
supply for irrigation in Eastern States, sources	899	7–9
Waterglass, use in preserving eggs, and use method	889	21–22
Watermelons, seed saving	884	6
Webworm, fall, injury to cotton, and control	890	15–16
Weeds—		
control—		
by cultivation and spraying, in oat fields, list	892	15–17
by oats crop	892	8
in rye	894	13
destruction for insect control in cotton	890	4, 26, 27
Weevil—		
cotton-boll, greatest cotton pest, injuries, habits, control, etc	890	16–17
cowpea-pod, injury to cotton, note	890	9

	Farmers' Bulletin No.	Page.
Wells, source of irrigation, water supply types	890	8–9
Wheat—		
acre value in food	877	4, 7
growing—		
in Great Plains, varieties, seeding rate and date	895	4–5
in Montana, eastern, details	878	10–15
in Utah, dry lands, details	883	14–18
in western North and South Dakota, details	878	10–15
rotations in Southeastern States	885	5–8
Southeastern States	885	1–14
pests, control	885	8–10
seeding, time and method, in Southeastern States	885	6–8
Southeastern States, yields, average for 10 years	885	3
thrashing and storing, practices in Southeastern States	885	14
varieties for Great Plains	895	4
winter, growing on the Great Plains	895	1–12
WHITE, WILLIAM, bulletin on "Making butter on the farm"	876	1–23
Williston experiment station, location and farming conditions	878	3–6
Willows, description, uses, and planting details	888	8, 19
Windbreaks, trees adapted to Plains region	888	6, 8, 9, 10, 11, 13, 19
Wireworms, injury to cotton roots, description and control	890	22
Wounds, trees, protection	888	22
Wyoming—		
forest trees, species adaptable, and planting details	888	5–10, 19
winter wheat growing	895	8

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 876

MAKING BUTTER ON THE FARM

NOV 12 1930

BUTTER MAKING begins with the production of the milk. Good butter can be made only from good, clean-flavored cream. To obtain practically all the cream from the milk and have it in the best condition requires the use of a cream separator.

The thorough cleaning and sterilizing of all dairy utensils is essential to the production of butter of good flavor.

Cream for butter making should contain about 30 per cent butterfat. A gallon of such cream will yield about 3 pounds of butter.

Cream should be kept as cold as possible until time for ripening, when it should be warmed to from 65° to 75° F. and held at that temperature until a mild-acid flavor is developed.

A thermometer should always be used in order that the operator may know that proper temperatures have been obtained.

Cream that is overripe (too sour) makes poor butter.

The churning temperature should be such that (1) the churning will require from 30 to 40 minutes, and (2) the butter granules will be firm without being hard—usually from 52° to 60° F. in summer and from 58° to 66° F. in winter.

All churning utensils should be cleaned, scalded, and cooled before they are used.

The churn should be stopped when the butter granules are the size of grains of wheat.

The butter, in the granular condition, should be washed twice with pure water at about the same temperature as the buttermilk.

Buttermilk must be washed out, not worked out.

Salt should be added at the rate of about three-quarters of an ounce to the pound of butter.

Butter should be carefully worked until the salt is evenly distributed and a solid, smooth body is formed. The best butter has a waxy body, a bright appearance, and, when a slab is broken, a grain like broken steel.

Overworked butter has a sticky, salvy body, a dull, greasy appearance, and a gummy grain. It deteriorates more rapidly than properly worked butter.

Mottled butter is caused by the uneven distribution of salt.

Butter for market should be in prints, wrapped in parchment paper, and inclosed in paraffined cartons.

Butter that is to be put down for winter use should be made from pasteurized sweet cream.

Washington, D. C.
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MAKING BUTTER ON THE FARM.

By William White, *Dairy Manufacturing Specialist, Bureau of Dairy Industry.*

CONTENTS.

	Page.		Page.
Extent of farm buttermaking	1	Difficult churning	14
Quality and preparation of the cream	1	Making butter for storage	16
The process of churning	7	Equipment for farm buttermaking	18
Washing, salting, and working the butter	11	Plan for dairy house	19
Butter package	13	Summary of steps in making butter on the farm	20

EXTENT OF FARM BUTTERMAKING.

SINCE the introduction of the creamery system of butter manufacture into the United States the practice of making butter on the farm has gradually decreased and a marked change has taken place in the marketing of the product. The farm-made butter of to-day, instead of being shipped to the large markets, is consumed very largely at home and in the near-by towns or is shipped to renovating factories.

QUALITY AND PREPARATION OF THE CREAM.

To produce good butter it is necessary to begin with a good clean-flavored milk.[1] In some sections of the country it is customary to ripen and churn the whole milk instead of the cream. That practice, however, is inadvisable, because it requires a high churning temperature, which injures the quality of the butter and causes a considerable loss of butterfat in the buttermilk. It is also liable to result in too much water in the butter. For those reasons only the churning of cream will be considered. It is just as important to keep the milk clean and well flavored when the cream from it is to be made into butter as when the whole milk is to be churned, and of course the cream after skimming must be handled with equal care.

METHODS OF SEPARATING CREAM.

Cream may be separated from the milk by gravity or by a centrifugal separator. Gravity separation may be accomplished by the shallow-pan, the deep-setting, or the water-dilution method. The first two have been extensively used and are still in use where very few cows are milked. In the first method the milk is placed in shallow pans and set in a cool place for about 36 hours, usually in a cellar or a spring house, and sometimes in cold water, to permit the cream to rise. During that time the surface, as a rule, is exposed to the air and frequently the cream absorbs or develops objectionable flavors. The skim milk resulting from the removal of the cream by this method usually contains 0.5 to 1.5 per cent of butterfat; that is, one-eighth to one-third of all the butterfat in the whole milk. It is frequently sour also; its value for calf feeding is injured, and its use in the household limited.

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[1] Farmers' Bulletin 602, "Production of Clean Milk," will be sent free upon request.

By the deep-setting method the milk as soon as drawn from the cow is placed in a "shotgun" can,[2] which is placed in cold water, preferably ice water, for 12 hours. Because of the quick cooling to a low temperature the cream rises more quickly and completely than in the shallow-pan method and is skimmed before its fresh, sweet flavor has been lost. The resulting skim milk may contain as low as 0.2 per cent of butterfat, though often nearer 0.5 per cent, and is sweet. If the milk is not placed in ice water immediately after it has been drawn the loss of butterfat is still greater.

The dilution of milk with water has been used to some extent, in the belief that it aids creaming, but investigations have shown that the loss of butterfat is as great as, or greater than, in the shallow-pan method. There is the further objection that a watery flavor is imparted to the cream, and the usefulness of the skim milk is limited, mixtures of water and skim milk being undesirable either for household use or for calf feeding. The water-dilution method therefore is not advisable under any conditions.

A centrifugal separator gives by far the best results, because the separation is accomplished in a few minutes, while the milk is still warm. The skim milk usually contains only a trace of butterfat and is available for use at once, while perfectly fresh. Because of the ability of the mechanical separator to skim clean, it is a profitable investment unless the quantity of milk is very small.

THE USE OF A CREAM SEPARATOR.

A cream separator should be placed in the dairy house or dairy room where there are no odors to contaminate the milk and cream during separation. It must be set level and firmly fastened on a solid foundation so as to be rigid when in operation. If that is not done the running of the machine will cause the frame to vibrate, and as a result the bowl will wabble, the bearings wear quickly, and the separation of cream from the milk will not be complete; that is, butterfat will be lost in the skim milk. When setting up the separator, a spirit level should be used to insure that the upper surface of the bowl casing is level. If the machine is set upon wood, lag screws may be used to fasten it in place, if upon cement, a bolt should be set in the floor, exposing thread enough to extend through the frame of the machine and accommodate a nut. Bolts may be set in the cement when the floor is laid, or holes may be drilled, the bolts inserted, and molten lead poured around them until flush with the floor. When cold the lead will have shrunk and should be pounded in tight. Washers or other pieces of metal may be used at the bolts to make the machine level. An especially sanitary setting for a separator may be made by setting the machine upon pieces of ¾-inch pipe about 1½ inches long. The machine is then supported upon four short posts, which makes cleaning the floor much easier.

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[2] This type of can is shown in Figure 1 and is described under the heading "Equipment for farm buttermaking," p. 18.

A cream separator should be run according to the directions furnished by the manufacturer. Bearings and gearings should be kept clean, free from grit, and well lubricated with good oil. Special care should be used to run the machine at the speed recommended by the manufacturer. If a speed indicator is not used, the revolutions of the crank should be timed by a watch or a clock. In turning, even pressure should be maintained on the handle throughout the revolution, as jerking causes unequal wear on the bearings and the gears. The cream separator is probably the most delicate machine in general use on the farm, and should be handled with the care that its construction demands.

A separator does its best work only when run under proper conditions. It will not skim clean when (1) it is run too slowly; (2) the bowl wabbles or vibrates; (3) the milk is too cold, 90° F. being the minimum temperature for the best work; (4) the bowl parts are bent, dirty, or not properly assembled; (5) particles of foreign matter get into the bowl and partially obstruct the cream outlet; or (6) the milk is nearly sour. During the winter, in order to warm the bowl, some warm water should be run through the separator so that the first milk that enters will not be cooled below 90° F. When through separating, a small quantity of skim milk or warm water should always be used to flush the bowl in order that no cream may be wasted.

Like all other milk utensils, the separator should be cleaned thoroughly immediately after each time it is used. Merely flushing the bowl with warm water after use and taking it apart for washing but once a day is a filthy practice and must be condemned. All parts of the separator bowl, together with the other tinware, should first be rinsed with lukewarm water, then thoroughly scrubbed with a brush in warm water in which washing powder has been dissolved. Soap or soap powder is liable to leave a soapy film on the utensils and should not be used. Soda ash or one of the commercial dairy cleansing powders is satisfactory, as either is easily rinsed off. The utensils should then be sterilized by means of the farm sterilizer or boiled for five minutes. The use of a dish towel or cloth for drying is not necessary or desirable, because the hot utensils will dry of themselves, and in order that they may remain sterile they should be handled or touched as little as possible.

The thorough cleaning and sterilizing of all dairy utensils is essential to the production of butter of good flavor. Unclean utensils harbor bacteria that, when the utensils are used again, contaminate the milk and cream and develop bad flavors and thus injure the butter.

PROPER RICHNESS OF THE CREAM.

Thin cream has the same objectionable features for churning that whole milk has, though in a less degree. For that reason the cream separator should be regulated to deliver cream testing about 30 per cent butterfat, or so rich that 1 gallon will yield about 3 pounds of butter.

COOLING THE CREAM.

After separation, the cream should be placed immediately in cold water and stirred occasionally with a stirring rod until the temperature is below 60° F. at least, and preferably below 50° F. Cream should be stirred with an up-and-down motion, in order that it may acquire a uniform temperature throughout. Fresh cream should never be mixed with cream from previous skimmings until it has been thoroughly cooled, as the addition of warm cream raises the temperature of the older cream and hastens souring. Water is a much better cooling agent than air, because it is a better conductor of heat and is capable of absorbing greater quantities of heat. In cooling, the best results are obtained when ice water is used. A dairy farmer in a section where natural ice is produced should have an ice house and should fill it each winter.[3] If well water alone is used, it is necessary to change it several times a day. For that reason the cooling tank should be between the well and the stock tank, so that all water pumped for the stock passes through it. A spring or a stream of cold water is very satisfactory, because it performs the work continuously without attention.

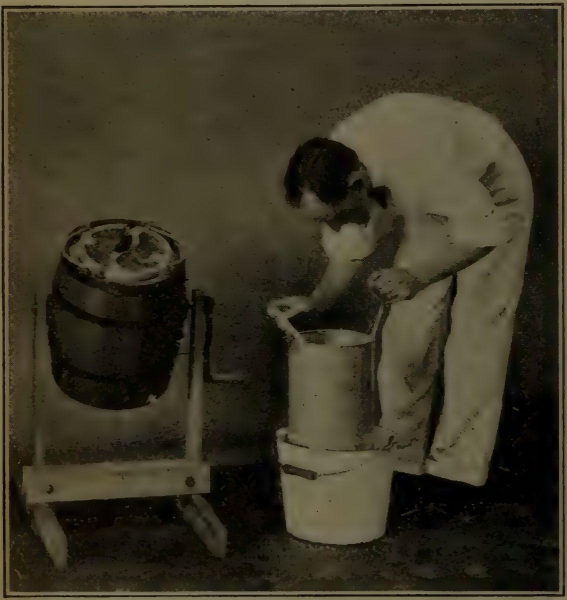

FIG. 1.—Cooling or warming the cream to the proper churning temperature.

Cooling tanks of various types may be obtained from dairy-supply houses or may be made on the farm. A satisfactory wooden tank may be made of 2-inch planed cypress boards properly bolted together, painted on the outside and oiled on the inside. Concrete makes a most serviceable tank which can be constructed by anyone accustomed to working with that material. A very simple and cheap cooling tank may be made also from two or more vinegar barrels—one for each cream can. Whatever the style of tank, the pipe conveying the water to it should be large enough to carry the full stream from the pump. Upon entering, the inlet pipe should be carried to within a few inches of the bottom by means of an ell and a short piece of pipe, so that the cold water may be conducted to the bottom, thus forcing the warmer water at the top through the outlet pipe.

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[3] Farmers' Bulletin 1078, "Harvesting and Storing Ice on the Farm," may be obtained from the United States Department of Agriculture free upon request.

The outlet pipe should be at the end of the tank opposite the inlet pipe, of slightly larger diameter, and so high that the water will be nearly at the tops of the cans. Lock nuts and sheet packing may be used to make tight joints where pipes enter and leave the tank. Cream cans should stand on cleats in the tank, so that water may circulate under as well as around them.

In order to afford protection from the heat, a cooling tank should have a tight cover and be placed in the dairy house or under a shed, where it will be protected from the hot winds and direct rays of the sun. If water does not flow continuously through the tank, it may be advisable to insulate the tank, as an insulated tank uses less ice and requires less frequent changing of water than an ordinary one. Tanks of that type may be purchased at a reasonable cost, or the insulation may be put on at home. To insulate a tank at the lowest possible cost, 6 inches of dry excelsior, shavings, or sawdust tightly packed on the sides, bottom, and cover of the tank will serve the purpose if kept dry.

RIPENING THE CREAM.

On many farms it is customary to churn only two or three times a week. Where this is the case the cream from each separation should be kept in the cooling tank until about 12 hours before churning. In order that the cream may ripen uniformly, it should be placed in one receptacle, thoroughly mixed, and warmed slowly to a temperature of from 65° to 75° F. Frequent stirrings with the stirring rod and the use of a thermometer are necessary to insure uniform and proper temperature throughout. Fresh cream should not be added after ripening has begun. The cream should be allowed to stand at the ripening temperature (from 65° to 75° F. until it thickens, assumes a glossy appearance, and is mildly sour, when it should be cooled quickly to churning temperature or below. (The churning temperature is usually from 52° to 60° F. in the summer and 58° to 66° F. in the winter.) This cooling may be done if the cream is in a can by placing it in the cooling tank and stirring it occasionally. Ice or cold water should never be put into the cream. In order that the butter may have the desired firmness of body, the cream should be held at churning temperature or slightly below for at least two hours before it is churned. Even after it is cooled the cream will continue to sour somewhat, but when ready for churning it should still be only mildly sour, not to exceed 0.6 per cent acidity, as determined by the acidity test.

Special care should be taken to prevent the cream from becoming too sour, which has two harmful results—it gives the butter a sour, overripe cream flavor, and injures its keeping properties.

The souring of cream is caused by the growth of bacteria, which are a simple form of plant life. Some bacteria produce lactic acid and, as a by-product, the flavors that are desirable in butter. Many other types of bacteria, however, grow and produce bad flavors at the temperature used for ripening cream. If the milk or cream has been contaminated by unclean methods during milking or by utensils that have not been properly cleaned and sterilized, "off flavors" will develop in the cream during ripening and will be retained in the butter. Undesirable flavors may be developed even in clean cream if the ripening temperature is too high or too low or if the cream becomes overripe: in fact, an overripe cream flavor is one of the most common defects in farm butter.

The organisms that develop the desirable lactic acid and its attendant flavors in the cream are very susceptible to the influence of temperature. Although they grow and produce acid in a very wide range of temperature, the flavors that are desired in butter are produced only within a very narrow range. It is therefore very essential to use an accurate thermometer and to control the ripening temperature carefully. Lactic-acid bacteria are more active in summer than in winter, and for that reason, together with the fact that the temperature of the cream during ripening is usually affected somewhat by the atmospheric temperature, it is well to begin the ripening process at a higher temperature in winter than in summer. Experience will demonstrate just how to handle the cream so that it will be in the proper condition when it is desired to churn.

STARTERS.

In creameries it is customary to control to some extent the ripening of cream by means of "starters," which are pure cultures of lactic-acid-producing bacteria grown in pasteurized milk. The making of starters is technical work that should not be undertaken unless butter is made on a commercial scale. If the milk and cream are produced under proper conditions, there is no need for using starters. If handled under those conditions and protected from contamination, cream will develop the desired flavor when allowed to ripen or sour naturally at the proper temperatures.

When butter is made on a commercial scale, it may be advisable to control the ripening and thus make a product that is more uniform from week to week.

Commercial cultures for starter making may be obtained from culture manufacturers and from dairy-supply houses. Directions for using accompany each package and should be followed carefully.

A natural or homemade starter may be made as follows:

1. Clean thoroughly and boil for five minutes three pint fruit jars and tops. After boiling, keep the jars covered to prevent the entrance of bacteria.

2. Take a pint sample of milk freshly drawn from each of three cows, place in the jars, cover, cool to 75° F., and keep at that temperature until curdling occurs.

3. Curdling, or coagulation, should take place in about 24 hours. An ideal curd should be firm, smooth, marblelike, free from holes or gas bubbles, and should show little or no separation of the whey. It should have a clean, sharp, sour or acid flavor.

4. Select the sample that most closely meets those conditions and propagate it, discarding the others. The selected sample is propagated as follows:

(*a*) Clean thoroughly and boil for five minutes a quart jar, the top, and a teaspoon.

(*b*) Fill the jar with freshly drawn milk, cover loosely, heat slowly to boiling, and pasteurize by boiling gently for 30 minutes.

(*c*) Cool the milk to 75° F. and add a teaspoonful of curdled milk described in section 3 and set away to curdle at that temperature.

(*d*) Propagate the starter from day to day in the same manner described in (*a*), (*b*), and (*c*). The starter described in (*c*) is the one to use for ripening the cream, and should be added in such quantities as to be one-tenth to one-fifth of the cream to be churned. Starter is put into the cream while the latter is being warmed to the ripening temperature. The ripening process with starter is exactly the same as natural souring except that it takes place in a shorter time.

THE PROCESS OF CHURNING.

THE PROPER TEMPERATURE.

The desirable temperature at which to churn is that which makes the butter granules firm without being hard. This is usually obtained under normal conditions when the churning occupies 30 or 40 minutes. The churning temperature necessary depends upon the season of the year and certain other factors, but is usually from 52° to 60° F. in the summer and from 58° to 66° in the winter. If the cream is churned at 62° F. in winter, and the butter comes in 35 minutes, with the granules firm, it will be noticed, as summer approaches and the cows are turned out to pasture, that the cream churns more quickly and the butter is softer. This is an indication that a lower churning temperature should be used, and thus from season to season the churning temperature is regulated so that the butter granules may have the proper firmness.

When the temperature is either too low or too high, undesirable results are obtained. A low temperature prolongs the churning period unnecessarily, and may even make it impossible to churn butter. It causes the granules, especially when the cream is thin, to form in tiny pellets, like fine shot, many of which run out with the buttermilk. The working of the butter and the incorporation of the salt are accomplished only with great difficulty, and the body of the butter is liable to be brittle and tallowy. Adding hot water to cream to warm it, and using wash water more than 3° warmer than the butter in order to soften it, are bad practices, since they injure the quality of the butter. If the proper churning temperature is used, the butter granules will be of the proper firmness.

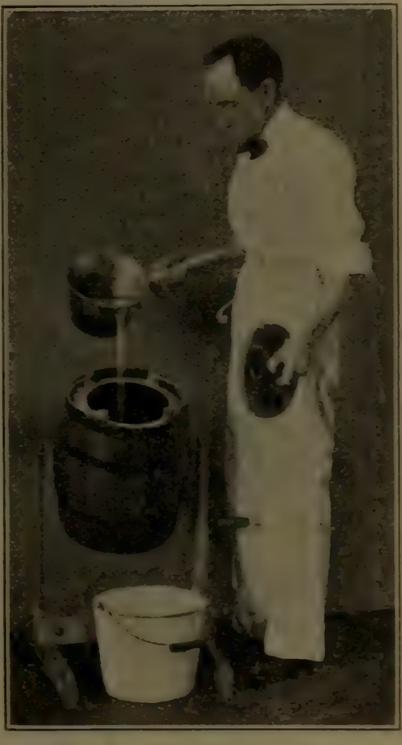

Fig. 2.—Preparing the churn.

Too high a churning temperature in churning is even more to be avoided, because it is directly responsible for the following undesirable results:

1. Loss of butterfat in the buttermilk. When the churning temperature is high enough to reduce the churning period to about 10 minutes, the loss of butterfat in the buttermilk may be as great as 1 or 2 per cent, whereas, under proper conditions, the loss usually does not exceed 0.2 per cent.

2. Injury to the quality of the butter.

(*a*) Too much buttermilk in the butter. When the butter granules are so soft that they do not remain distinct, but stick together in large masses, the washing out of the buttermilk is greatly interfered with and abnormally large quantities of it are incorporated into the butter. Butter of that kind has poor keeping qualities and quickly develops bad flavors. Other things being equal, the less buttermilk or curd in butter the better are its keeping qualities. The "off flavors" that so quickly develop in much of the farm-made butter are not produced by decomposition of the butterfat, but by decomposition of the milk solids which are found in the buttermilk. Because the drops of moisture expressed from the butter are milky in appearance, the butter is said to have a milky brine and for that reason is discriminated against.

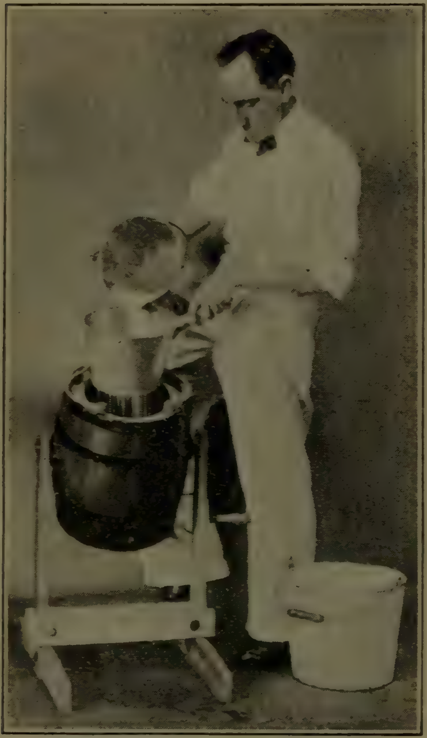

Fig. 3.—Straining cream into churn.

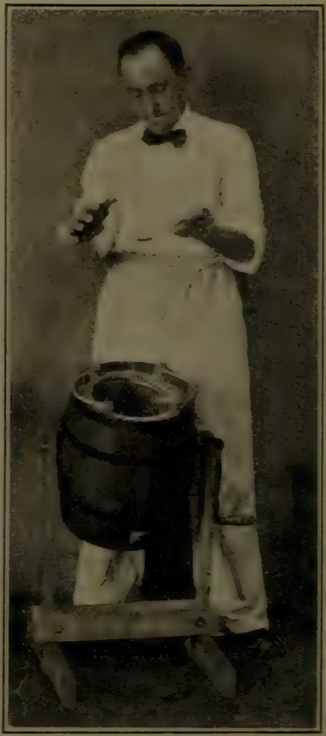

Fig. 4.—Adding butter color.

(*b*) "Leaky" butter and too much moisture. Butter that "comes soft" retains large quantities of moisture from the buttermilk and wash water. Because of the softness of the butter the moisture is not well incorporated, but is found in pockets and large drops. Upon the butter standing some of the moisture oozes out, or, when the butter is cut, large drops appear on the cut surface. Such butter is said to be "leaky." That fault is objectionable in itself and has the additional objection of causing a material shrinkage in the weight of the butter.

(*c*) A weak, salvy body. Butter properly made has a firm, waxy body, but high temperatures during manufacture make it soft and of a salvy consistency. When eaten it seems to melt slowly and stick to the mouth, in contrast to the quickly melting and quickly disappearing butter with a firm, waxy body.

The use of the proper churning temperature is therefore essential to the production of first-class butter, which means that the churning period must occupy 30 or 40 minutes. There is no short cut in churning. Patent churns that churn butter in seven minutes produce practically the same harmful results as those just described.

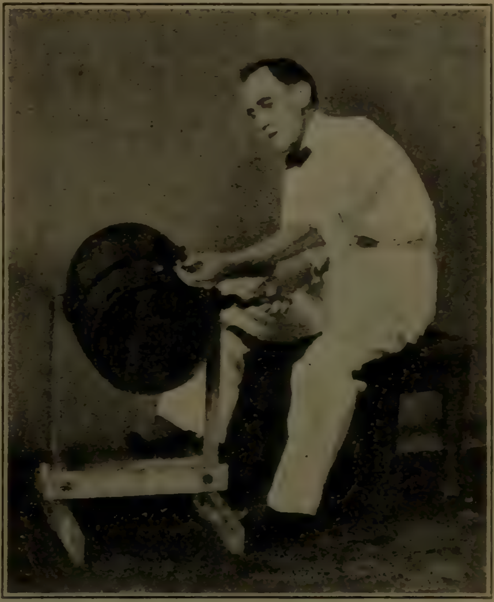

FIG. 5.—Allowing gas to escape.

PREPARING THE CHURN.

When cream is ready for churning the churn should be prepared for use by cleaning it thoroughly, rinsing it with scalding water, and then thoroughly rinsing and chilling with cold water.

The butter ladles, paddles, worker, and printer should be treated in the same way, and all but the worker placed in a pail of cold water until needed. If that is not done, the butter will stick to them.

PUTTING THE CREAM INTO THE CHURN.

Cream should be poured into the churn through a strainer to break up possible lumps and to remove curd particles and any foreign matter that may be in it. In order to have the necessary concussion the churn should be only about one-third full. If too full, the churning period is prolonged, and if the cream foams it nearly fills the churn and prevents concussion. In that case it is usually necessary to remove some of the cream in order to obtain butter in a reasonable time.

ADDING BUTTER COLOR.

Except late in the spring and early in the summer, when butter has a naturally high color, a small quantity of butter color is usually added. In winter the quantity required to produce a shade of yellow like the desirable June color varies from about 20 to 35 drops per gallon of cream.

The color having been added to the cream, the churn may be started at a speed to produce the greatest concussion, which can be determined largely by the sound. About 60 revolutions a minute is the usual speed for the common barrel type of churn. After a few revolutions the churn should be stopped, bottom up, and the cork removed to permit the escape of gas. (See fig. 5.) This is repeated two or three times in the early stages of churning. At that period cream produces a very liquid sound, and the glass in the churn is evenly covered with cream.

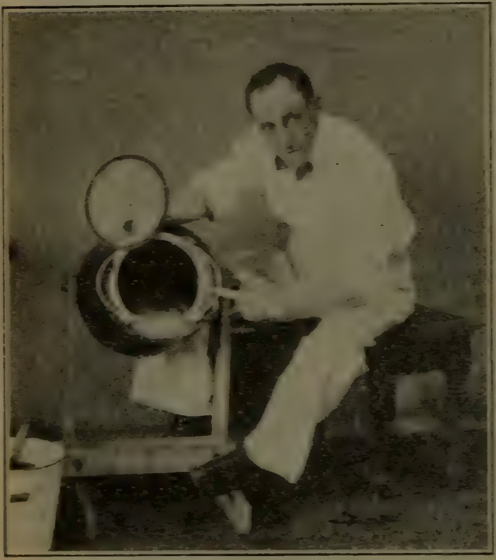

FIG. 6.—Churning completed. From 30 to 40 minutes of churning is usually necessary to obtain butter particles the size of wheat kernels.

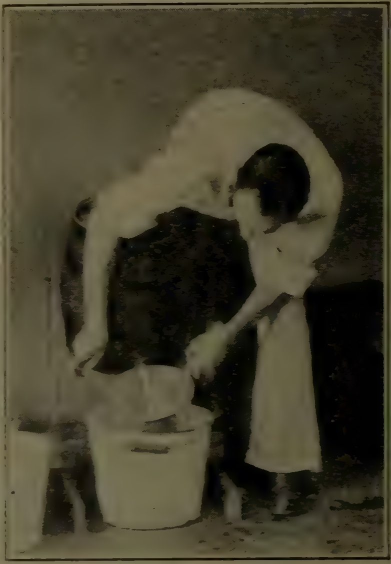

FIG. 7.—Drawing off the buttermilk.

When churning is nearly completed there is a noticeable difference in the sound made by the cream, while on the glass in the churn a thick, mushy mass will appear, which occasionally breaks away, leaving the glass clear. At this point the butter granules are just forming, and the cream is thick and finely granular, like yellow cornmeal mush, with buttermilk separating slightly from the tiny granules. The churn should be revolved several times, then stopped and the butter examined in order to prevent overchurning. When the granules are the size of grains of wheat the churning is completed. To continue the churning until the butter is in large masses is a bad practice, because it incorporates quantities of buttermilk which can not be washed out.

Churning completed, the buttermilk is drawn through the hole at the bottom of the churn and is run through a strainer to catch any particles of butter. (See fig. 7.)

WASHING, SALTING, AND WORKING THE BUTTER.

WASHING.

The object of washing butter is to remove the buttermilk. The only way that this can be done properly is to wash the butter when it is in small granules so that the largest possible surface is exposed to the water. To try to remove buttermilk by working it out of the butter is not effective; moreover, the excessive working injures the grain and body of the butter.

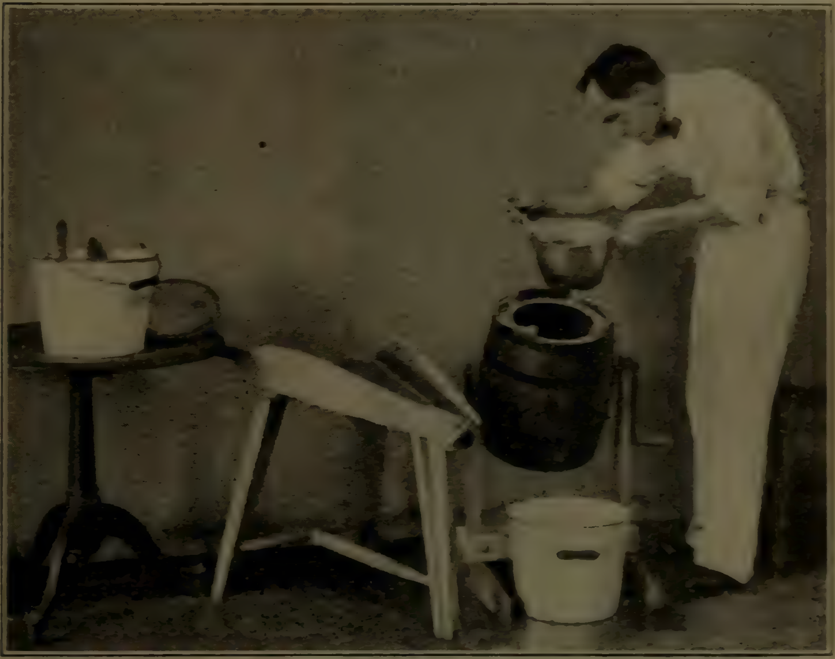

Fig. 8.—Taking temperature of wash water.

While the last of the buttermilk is draining off the wash water should be prepared. Only pure, clean wash water should be used, and it should be twice the quantity of and at about the same temperature as the buttermilk. The water should be placed in a pail or other receptacle and its temperature determined with a thermometer; if necessary it should be tempered by the addition of either warm water or ice. If the butter granules are too soft or too hard the temperature of the wash water may be either a few degrees warmer or colder than the buttermilk. Warm water has the same effect upon the body of the butter as high churning temperatures, whereas cold water makes the butter so hard that it can be worked only with great difficulty, and if very cold the proper incorporation of the salt is practically impossible.

After the buttermilk has been drawn off, the cork is replaced and one-half the wash water is poured into the churn. The cover of the churn is then replaced and the churn given about four rapid revolutions. The wash water is drawn off and the washing repeated. Two washings are usually sufficient, the second wash water when drawn off usually being almost perfectly clear.

SALTING AND WORKING.

While the wash water is draining off the worker should be rinsed again with hot water followed by a thorough rinsing and cooling with cool water. This must be done immediately before using, because if the worker is slightly dry the butter will stick to it. The lever worker is widely used and gives satisfactory results, though other types do just as good work.

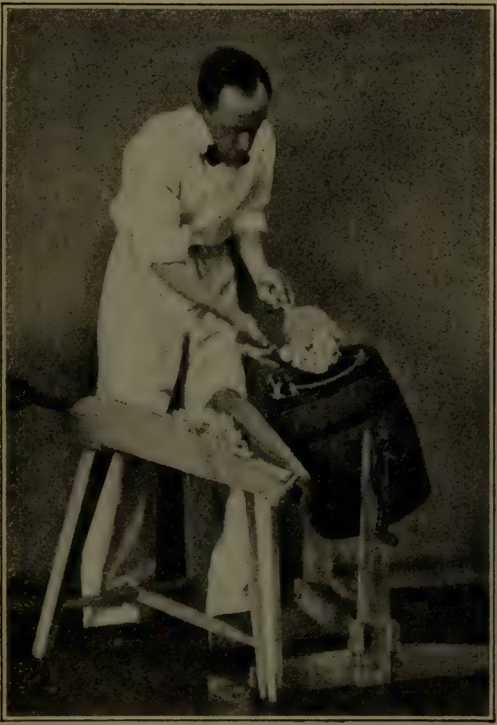

FIG. 9.—Removing the butter from the churn.

The butter, which is still in the granular condition, is removed from the churn with the ladle and placed in a convenient receptacle for weighing. The old-fashioned butter bowl is convenient, and this is the only use that should be made of it. The butter having been weighed the quantity of salt is calculated on the basis of three-fourths of an ounce for each pound of butter. The quantity may be varied to suit personal taste or the requirement of the market. The best grade of butter salt or table salt should be used. The butter is placed upon the worker, spread out about 2 inches thick, and the salt, free of lumps, sifted upon it. The butter is then pressed with the lever or other device, care being taken to press and not to rub or smear it. After being pressed into a thin layer it is folded upon itself into a pile and the pressing repeated. The working is continued until there is a thorough and even distribution of the salt and a desirable grain and body have been produced.

The working of the butter is a very important step in the making process and should receive careful attention. Too much working is a common fault in farm-made butter. Overworked butter has a sticky and salvy body, a dull, greasy appearance, and gummy grain. It feels warm in the mouth, sticks, and dissolves slowly. Properly worked butter has a waxy body and a bright appearance, and feels cool and dissolves quickly in the mouth. Butter has a proper grain if a slab breaks when bent at an angle of about 45° and the broken surface has the appearance of broken steel. In addition, overworking butter injures its keeping properties.

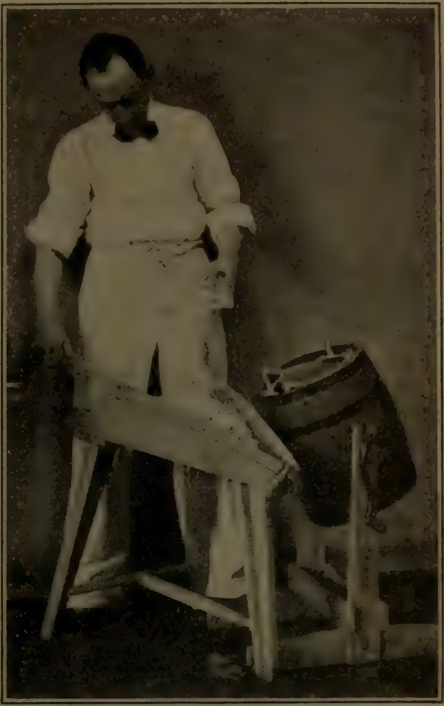

FIG. 10.—Salting the butter.

When butter is underworked it is brittle, may be gritty because of undissolved salt, and, worst of all, may be mottled or uneven in color. The latter fault is common, and the purchaser who is not versed in buttermaking sometimes thinks it is due to mixing light- and deep-colored butter, and for that reason mottled butter is strongly discriminated against on the market. Mottles are caused by the uneven distribution of salt, the deeper-colored streaks or spots containing more salt than those of lighter color. To prevent that condition the butter must be worked until the salt is evenly distributed throughout the butter. When underworked, especially if highly salted, the butter is liable to be gritty because of undissolved salt. That fault will not occur in properly worked butter unless an excess of salt has been added. Butter that is cold and very firm requires more working than butter that is comparatively soft.

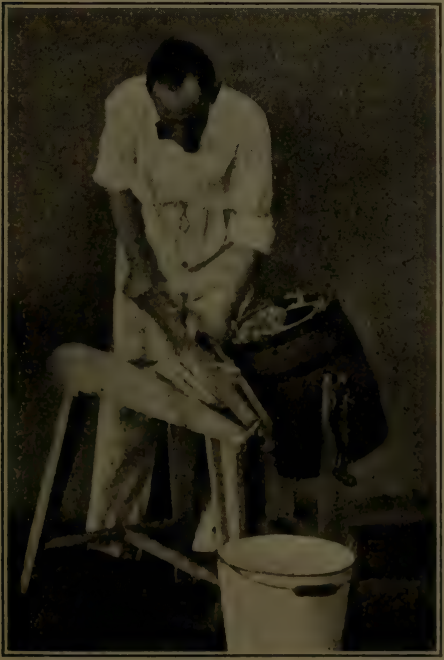

FIG. 11.—Working the butter.

BUTTER PACKAGES.

For home use butter is frequently packed into glazed earthenware crocks, which are very satisfactory and convenient receptacles for butter on the farm. If the glazing is imperfect, however, the crocks absorb butter and soon become very insanitary.

For market the rectangular 1-pound print is the most desirable form. It presents a more attractive appearance than the crock or "country roll," is more convenient and easily handled, and can be inserted into a carton which not only protects the butter but also adds greatly to the appearance of the package. To make prints, the printer is pressed upon the butter on the table until it is completely filled, the surplus is then scraped off with the paddle and the print pressed out on parchment wrapping paper. In order that the prints may weigh exactly a pound the printer should be carefully regulated and an occasional print weighed on an accurate scale. Prints for market should be wrapped in white parchment paper made for the purpose, 8 by 11 inches in size, and placed in paraffined cartons, upon which may appear the name of the farm or brand.

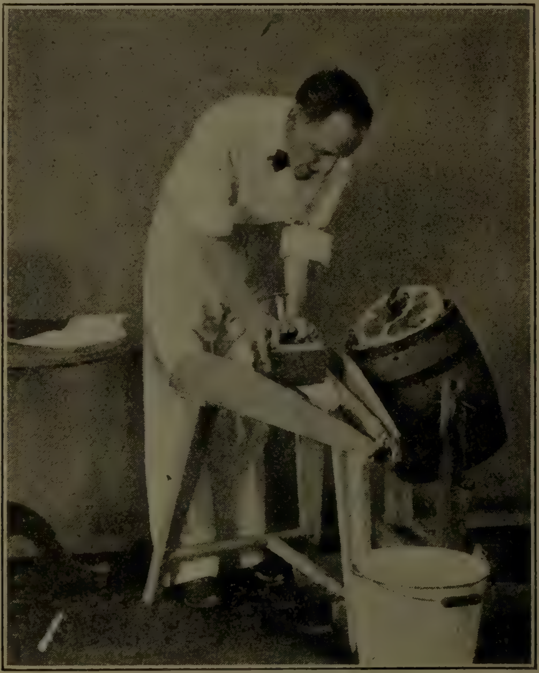

FIG. 12.—Printing butter.

After printing and wrapping, the butter should be placed in a refrigerator or other cool place.

The churning utensils should then receive immediate attention. They should all be thoroughly cleaned by means of a hand brush, hot water, and dairy cleanser or washing powder, and thoroughly rinsed with boiling water. To place them in the sunshine or occasionally wash them with limewater aids in keeping them sweet.

DIFFICULT CHURNING.

The farm buttermaker sometimes fails to obtain butter after churning the usual length of time; in fact, the churning is sometimes prolonged for several hours without obtaining butter. The causes of the difficulty, together with the remedies, are as follows:

1. Churning temperature too low. It may be necessary, under exceptional conditions, to raise it to between 65° and 70° F.

2. Cream too thin or too rich. It should contain about 30 per cent butterfat.

3. Cream too sweet. If ripened to a moderate acidity it will churn more easily.

4. Churn too full. In order to obtain the maximum concussion the churn should be not more than one-third full.

5. Ropy fermentation of the cream preventing concussion. This may be prevented by sterilizing all the utensils and producing the milk and cream under the most sanitary conditions. If additional measures are needed, the pasteurization of the cream, with subsequent protection from contamination, and ripening it with a good starter, will be effective.

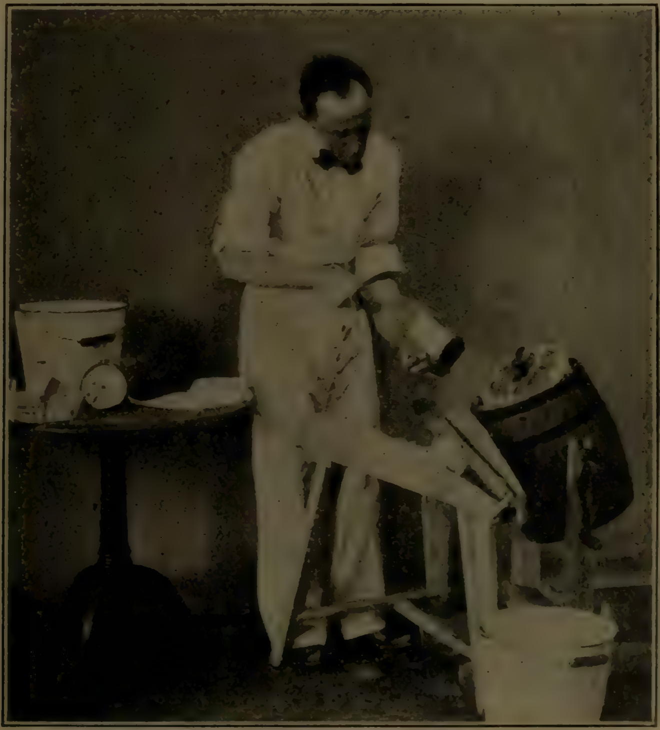

FIG. 13.—Leveling off the print.

6. Individuality of the cow. The only remedy is to obtain cream from a cow recently fresh, or cream that is known to churn easily, and before ripening mix it with the cream that is difficult to churn.

7. The cow being far advanced in the period of lactation. The effects may be at least partially overcome by adding, before ripening, some cream from a cow that is not far advanced in the period of lactation.

8. Feeds that produce hard fat. Such feeds are cottonseed meal and timothy hay. Linseed meal, gluten feed, and succulent feeds such as silage and roots tend to overcome the condition.

MAKING BUTTER FOR STORAGE.

In summer there is usually a surplus of milk, and prices are lower; farmers therefore often find it desirable at that season to make a supply of butter for winter use. Such butter must have good keeping qualities in order that the least possible deterioration may take place. Butter which will keep fairly well may be made from cream ripened to a mild sour flavor. To make butter of superior keeping qualities, however, it is advisable to churn sweet cream which has been pasturized. Pasteurization consists in heating the cream to such a temperature that most of the bacteria in it are destroyed. Butter made from pasteurized sweet cream keeps much better than that made from raw ripened cream.

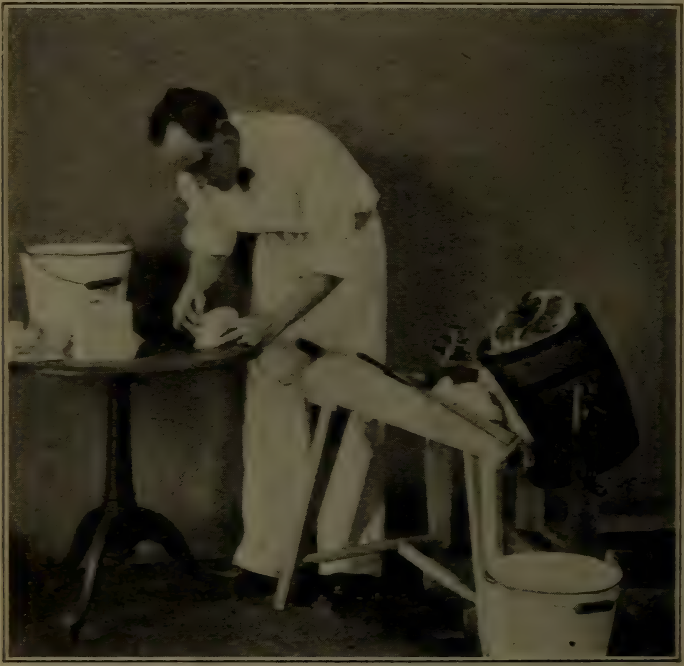

FIG. 14.—Wrapping print butter in parchment paper.

Cream may be pasteurized on the farm by placing shotgun cans or pails containing cream in a wash boiler or other suitable container partly filled with water and set on a stove. The cream should be stirred occasionally while being heated, and should be brought to a temperature of from 145° to 150° F., and held at that temperature for 25 or 30 minutes. It should then be cooled as quickly as possible to 50° F., or lower, and held at that temperature for at least three hours before being churned, in order that the butter granules may be firm. The cream may be cooled by running cold water into the boiler or by setting the cream cans in the cooling tank, as described on pages 4 and 5.

The churning is done in the same manner as when ripened raw cream is churned. It is especially desirable, however, to have the churning occupy at least 30 minutes, in order that loss of fat in the buttermilk may be avoided.

PACKING AND STORING.

The butter should be well packed into earthenware crocks or wooden tubs, which should be thoroughly scalded and cooled just before they are filled. The butter should then be covered with paraffin to keep it from spoiling on the surface.

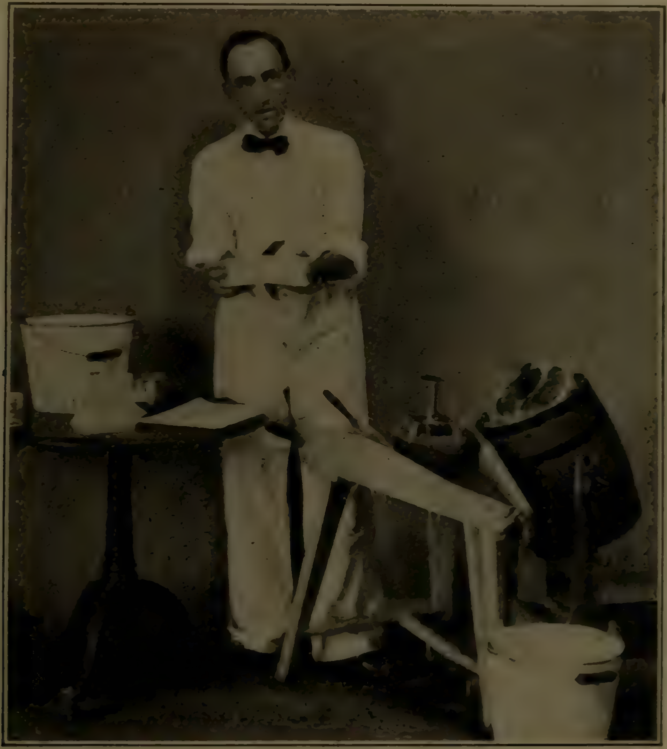

FIG. 15.—Inserting butter print into carton.

Butter may also be made into rolls or prints and immersed in a saturated brine made by dissolving 1 pound of salt in 4 pounds of water. The butter should be wholly submerged in order that it may not be exposed to the air.

The crocks of butter should be kept in the coolest place available, which in summer is probably the cellar. As soon as the weather is cool, however, the butter should be moved to a place where it is exposed to the outside cold. The colder the butter is the better it keeps. In commercial cold storage it is kept at zero Fahrenheit.

EQUIPMENT FOR FARM BUTTERMAKING.

The following equipment is needed for buttermaking on the farm:

1. *Milk pails.*—They should be of the type commonly known as covered-top, should be heavily tinned, and have all seams flushed with solder so that they can be cleaned easily.

2. *Cream separator.*—Any make is satisfactory if it skims clean and can be thoroughly cleaned and sterilized.

3. *Shotgun cans.*—As a cream container the style of can known as the "shotgun can" is much to be preferred to crocks and many other types of cans and pails commonly used. This can usually measures about 8½ inches in diameter and 20 inches high. One is shown in Figure 1. These cans are easily handled, covered, and cleaned.

4. *Cream-cooling tank.*—Where there is an abundance of cold water any tank, properly used, will be effective. In very warm climates or where cold water can not be run through the tank several times daily, or where ice is used, it is advisable to use an insulated tank.

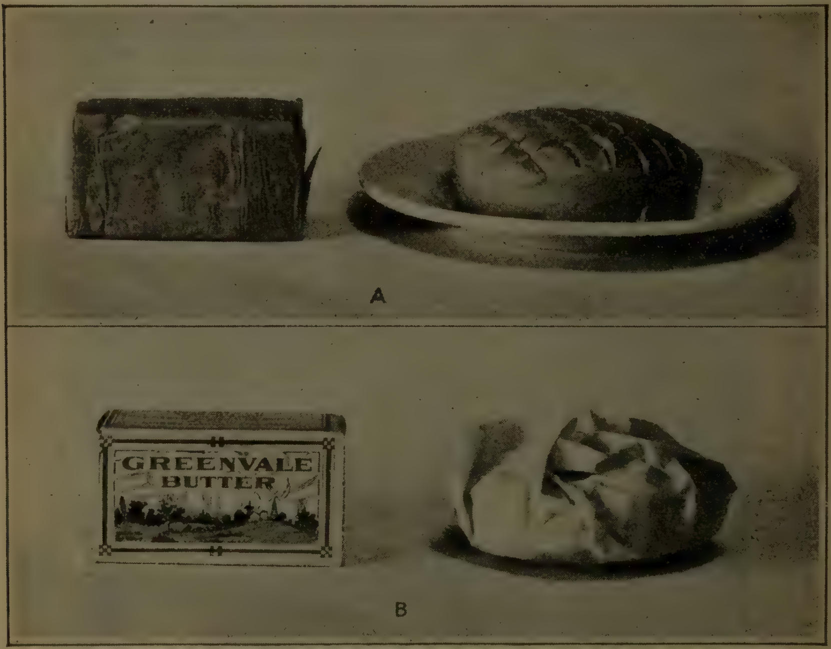

FIG. 16.—Packages of country butter. The rectangular shape is better for marketing.

5. *Churn.*—The barrel type of churn (shown in several of the illustrations) is simple, inexpensive, easy to operate, and easily cleaned.

6. *Butterworker.*—The lever and the table butterworkers are very satisfactory. The former (fig. 11) is simpler and less expensive. When making large quantities of butter a table worker or combined churn and worker is frequently used.

7. *Thermometer.*—A floating dairy thermometer should be used.

8. *Cream and buttermilk strainer.*—A strainer similar to a colander or a strainer dipper is frequently used for straining both the cream and buttermilk. A hair sieve is sometimes used as a buttermilk strainer because butter does not stick to it as it does to tinware.

9. *Cream-stirring rod.*—A rod with a 4 or 5 inch disk on one end is more effective in stirring cream than a spoon or other implement. Stirring rods should be well tinned and smooth so that they may be cleaned easily.

10. *Wooden paddle.*

11. *Wooden ladle.*

12. *Tin pails.*

Fig. 17.—Washing butter utensils.

13. *Half-gallon tin dipper.*

14. *Hand butter printer.*

15. *Scrub brush.*—A stiff-fiber brush is preferable to one with soft bristles.

PLAN FOR DAIRY HOUSE.

A conveniently arranged dairy house is very desirable in making butter on the farm, especially if any considerable quantity is produced. A small, simple building usually answers the purpose. A plan showing the principal features of such a house and a good arrangement of the equipment is shown in Figure 18.[4]

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[4] Various other plans of dairy houses designed for specific uses, where the product is marketed in various ways, may be found in Farmers' Bulletin 1214, "Farm Dairy Houses."

SUMMARY OF STEPS IN MAKING BUTTER ON THE FARM.

1. Produce clean milk and cream. Cool the cream immediately after it comes from the separator. Clean and sterilize all utensils.
2. Ripen the cream at from 65° to 75° F. until mildly sour. Always use a thermometer in order to know that the right temperature is reached.
3. Cool the cream to churning temperature or below, and hold at that temperature for at least two hours before churning.
4. Use a churning temperature—usually between 52° and 66° F.—that will require 30 or 40 minutes to obtain butter.
5. Clean and scald the churn, then half fill it with cold water and revolve until churn is thoroughly cooled, after which empty the water.

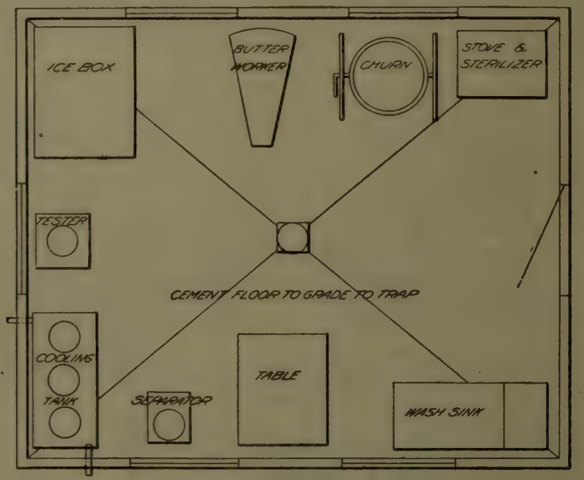

FIG. 18.—Plan of dairy house.

6. Pour the cream into the churn through a strainer.
7. Add butter color—from 20 to 35 drops to a gallon of cream—except late in the spring and early in the summer.
8. Put the cover on tight; revolve the churn several times; stop with bottom up, and remove stopper to permit escape of gas; repeat until no more gas forms.
9. Continue churning until butter granules are formed the size of grains of wheat.
10. Draw off the buttermilk through the hole at the bottom of the churn, using a strainer to catch particles of butter. When the buttermilk has drained out, replace the cork.
11. Prepare twice as much wash water as there is buttermilk, and at about the same temperature. Use the thermometer; do not guess at temperatures. Put one-half the water into the churn with the butter.
12. Replace the cover and revolve the churn rapidly a few times, then draw off the water. Repeat the washing with the remainder of the water.

13. The butter should still be in granular form when the washing is completed.

14. Weigh the butter.

15. Place the butter on the worker and add salt at the rate of three-quarters of an ounce to a pound of butter.

16. Work the butter until the salt is dissolved and evenly distributed. Do not overwork it.

17. Pack in any convenient form for home use, or make into 1-pound prints for market, wrapping the butter in white parchment paper and inclosing in a paraffined carton.

18. Clean the churn and all buttermaking utensils.

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February 1, 1930

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MAKING BUTTER ON THE FARM

WILLIAM WHITE

Dairy Division

See revised edition unbound in front

FARMERS' BULLETIN 876

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Animal Industry

A. D. MELVIN, Chief

Washington, D. C. September, 1917

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BUTTERMAKING begins with the production of the milk. Good butter can be made only from good, clean-flavored cream. To obtain practically all the cream from the milk and have it in the best condition requires the use of a cream separator.

The thorough cleaning and sterilizing of all dairy utensils is essential to the production of butter of good flavor.

Cream for buttermaking should contain about 30 per cent butterfat. A gallon of such cream will yield about 3 pounds of butter.

Cream should be kept as cold as possible until time for ripening, when it should be warmed to from 65° to 75° F. and held at that temperature until a mild-acid flavor is developed.

A thermometer should always be used in order to know that proper temperatures have been obtained.

Cream that is overripe (too sour) makes poor butter.

The churning temperature should be such that (1) the churning will require from 30 to 40 minutes, and (2) the butter granules will be firm without being hard—usually from 52° to 60° F. in summer and from 58° to 66° F. in winter.

All churning utensils should be cleaned, scalded, and cooled before they are used.

The churn should be stopped when the butter granules are the size of grains of wheat.

The butter, in the granular condition, should be washed twice with pure water at about the same temperature as the buttermilk.

Buttermilk must be washed out, not worked out.

Salt should be added at the rate of about three-quarters of an ounce to the pound of butter.

Butter should be carefully worked until the salt is evenly distributed and a solid, smooth body is formed. The best butter has a waxy body, a bright appearance, and, when a slab is broken, a grain like broken steel.

Overworked butter has a sticky, salvy body, a dull, greasy appearance, and a gummy grain. Its keeping properties are not so good as in properly worked butter.

Mottled butter is caused by the uneven distribution of salt.

Butter for market should be in prints, wrapped in parchment paper, and inclosed in paraffined cartons.

MAKING BUTTER ON THE FARM.

CONTENTS.

	Page.		Page.
Extent of farm buttermaking	3	Difficult churning	18
Quality and preparation of the cream	3	Equipment for farm buttermaking	20
The process of churning	10	Plan of dairy house	21
Washing, salting, and working the butter	14	Summary of steps in making butter on the farm	22
Butter packages	17		

EXTENT OF FARM BUTTERMAKING.

SINCE the introduction of the creamery system of butter manufacture into the United States the practice of making butter on the farm has gradually decreased and a marked change has taken place in the marketing of the product. The farm-made butter of to-day, instead of being shipped to the large markets, is consumed very largely at home and in the near-by towns or is shipped to renovating factories. In spite of the fact that on the large markets the creamery product has almost entirely supplanted dairy butter, more than half the butter in this country is made on the farms.

QUALITY AND PREPARATION OF THE CREAM.

To produce good butter it is necessary to begin with a good, clean-flavored milk.[1] In some sections of the country it is customary to ripen and churn the whole milk instead of the cream. That practice, however, is inadvisable, because it requires a high churning temperature, which injures the quality of the butter and causes a considerable loss of butterfat in the buttermilk. It is also liable to result in too much water in the butter. For those reasons only the churning of cream will be considered. It is just as essential to obtain cream under such conditions that it will be of equally good quality as the milk.

METHODS OF SEPARATING CREAM.

Cream may be separated from the milk by gravity or by a centrifugal separator. Gravity separation may be accomplished by the shallow-pan, the deep-setting, or the water-dilution method. The first two have been extensively used and are still in use where very few cows are milked. In the first method the milk is placed in shallow pans and set in a cool place for about 36 hours, usually in a cellar or a spring house, and sometimes in cold water, to permit the cream to rise. During that time the surface, as a rule, is exposed to the air and frequently the cream absorbs or develops objectionable flavors. The skim milk resulting from the removal of the cream by this method usually contains 0.5 to 1.5 per cent of butterfat; that is, one-eighth to one-third of all the butterfat in the whole milk. It is frequently sour also; its value for calf feeding is injured, and its use in the household limited.

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[1] Farmers' Bulletin 602, "Production of Clean Milk," will be sent free upon request.

By the deep-setting method the milk as soon as drawn from the cow is placed in a "shotgun" can,[1] which is placed in cold water, preferably ice water, for 12 hours. Because of the quick cooling to a low temperature the cream rises more quickly and completely than in the shallow-pan method and is skimmed before its fresh, sweet flavor has been lost. The resulting skim milk may contain as low as 0.2 per cent of butterfat, though often nearer 0.5 per cent, and is sweet. If the milk is not placed in ice water immediately after it has been drawn the loss of butterfat is still greater.

The dilution of milk with water has been used to some extent, in the belief that it aids creaming, but investigations have shown that the loss of butterfat is as great as, or greater than, in the shallow-pan method. There is the further objection that a watery flavor is imparted to the cream, and the usefulness of the skim milk is limited, mixtures of water and skim milk being undesirable either for household use or for calf feeding. The water-dilution method therefore is not advisable under any conditions.

A centrifugal separator gives by far the best results, because the separation is accomplished in a few minutes, while the milk is still warm. The skim milk usually contains only a trace of butterfat and is available for use at once, while perfectly fresh. Because of the ability of the mechanical separator to skim clean, it is a profitable investment unless the quantity of milk is very small.

THE USE OF A CREAM SEPARATOR.

A cream separator should be placed in the dairy house or dairy room where there are no odors to contaminate the milk and cream during separation. It must be set level and firmly fastened on a solid foundation so as to be rigid when in operation. If that is not done the running of the machine will cause the frame to vibrate, and as a result the bowl will wabble, the bearings wear quickly, and the separation of cream from the milk will not be complete; that is, butterfat will be lost in the skim milk. When setting up the separator a spirit level should be used to insure that the upper surface of the bowl casing is level. If the machine is set upon wood, lag screws may be used to fasten it in place; if upon cement, a bolt should be set in the floor, exposing thread enough to extend through the frame of the machine and accommodate a nut. Bolts may be set in the cement when the floor is laid, or holes may be drilled, the bolts inserted, and molten lead poured around them until flush with the floor. When cold the lead will have shrunk and should be pounded in tight. Washers or other pieces of metal may be used at the bolts to make the machine level. An especially sanitary setting for a separator may be made by setting the machine upon pieces of $\frac{3}{4}$-inch pipe about $1\frac{1}{2}$ inches long. The machine is then supported upon four short posts, which makes cleaning the floor much easier.

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[1] This type of can is shown in fig. 1 and is described under the heading "Equipment for farm butter making," page 20.

A cream separator should be run according to the directions furnished by the manufacturer. Bearings and gearings should be kept clean, free from grit, and well lubricated with good oil. Special care should be used to run the machine at the speed recommended by the manufacturer. If a speed indicator is not used, the revolutions of the crank should be timed by a watch or a clock. In turning, even pressure should be maintained on the handle throughout the revolution, as jerking causes unequal wear on the bearings and the gears. The cream separator is probably the most delicate machine in general use on the farm, and should be handled with the care that its construction demands.

A separator does its best work only when run under proper conditions. It will not skim clean when (1) it is run too slowly, (2) the bowl wabbles or vibrates, (3) the milk is too cold, 90° F. being the minimum temperature for the best work, (4) the bowl parts are bent, dirty, or not properly assembled, (5) particles of foreign matter get into the bowl and partially obstruct the cream outlet, or (6) the milk is nearly sour. During the winter, in order to warm the bowl, some warm water should be run through the separator so that the first milk that enters will not be cooled below 90° F. When through separating, a small quantity of skim milk or warm water should always be used to flush the bowl in order that no cream may be wasted.

Like all other milk utensils, the separator should be cleaned thoroughly immediately after each time it is used. Merely flushing the bowl with warm water after use and taking it apart for washing but once a day is a filthy practice and must be condemned. All parts of the separator bowl, together with the other tinware, should first be rinsed with lukewarm water, then thoroughly scrubbed with a brush in warm water in which washing powder has been dissolved. Soap or soap powder are liable to leave a soapy film on the utensils and should not be used. Soda ash or one of the commercial dairy cleansing powders is satisfactory, as either is easily rinsed off. The utensils should then be sterilized by means of the farm sterilizer[1] or boiled for five minutes. The use of a dish towel or cloth for drying is not necessary or desirable, because the hot utensils will dry of themselves, and in order that they may remain sterile they should be handled or touched as little as possible.

The thorough cleaning and sterilizing of all dairy utensils is essential to the production of butter of good flavor. Unclean utensils harbor bacteria that, when the utensils are used again, contaminate the milk and cream and develop bad flavors and thus injure the butter.

PROPER RICHNESS OF THE CREAM.

Thin cream has the same objectionable features for churning that whole milk has, though in a less degree. For that reason the cream separator should be regulated to deliver cream testing about 30 per cent butterfat, or so rich that 1 gallon will yield about 3 pounds of butter.

COOLING THE CREAM.

After separation, the cream should be placed immediately in cold water and stirred occasionally from the bottom with a stirring rod until the temperature is below 60° F. at least, and preferably below 50° F. Fresh cream should never be mixed with cream from previous skimmings until it has been thoroughly cooled, as the addition of warm cream raises the temperature of the older cream and hastens souring. Water is a much better cooling agent than air, because it is a better conductor of heat and is capable of absorbing greater quantities of heat. In cooling, the best results are obtained when ice water is used. A dairy farmer in a section where natural ice is produced should have an ice house and should fill it each winter.[2] If well water alone is used, it is necessary to change it several times a day. For that reason the cooling tank should be between the well and the stock tank, so that all water pumped for the stock passes through it. A spring or a stream of cold water is very satisfactory, because it performs the work continuously without attention.

Cooling tanks of various types may be obtained from dairy-supply houses or may be made on the farm. A satisfactory wooden tank may be made of 2-inch planed cypress boards properly bolted together, painted on the outside and oiled on the inside. Concrete makes a most serviceable tank which can be constructed by anyone accustomed to working with that material. A very simple and cheap cooling tank may be made also from two or more vinegar barrels—one for each cream can. Whatever the style of tank, the pipe conveying the water to it should be large enough to carry the full stream from the pump. Upon entering, the inlet pipe should be carried to within a few inches of the bottom by means of an ell and a short piece of pipe, so that the cold water may be conducted to the bottom, thus forcing the warmer water at the top through the outlet pipe. The outlet pipe should be at the end of the tank opposite the inlet pipe, of slightly larger diameter, and so high that the water will be nearly at the tops of the cans. Lock nuts and sheet packing may be used to make tight joints where pipes enter and leave the tank. Cream cans should stand on cleats in the tank, so that water may circulate under as well as around them.

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[1] An excellent apparatus and method for sterilizing dairy utensils on the farm are described in Farmers' Bulletin 748, a copy of which will be sent free by the United States Department of Agriculture upon request.

[2] Farmers' Bulletin 623, "Ice Houses and the Use of Ice on the Dairy Farm," may be obtained from the United States Department of Agriculture free upon request.

In order to afford protection from the heat, a cooling tank should have a tight cover and be placed in the dairy house or under a shed, where it will be protected from the hot winds and direct rays of the sun. If water does not flow continuously through the tank it may be advisable to insulate the tank, as an insulated tank uses less ice and requires less frequent changing of water than an ordinary one. Tanks of that type may be purchased at a reasonable cost, or the insulation may be put on at home. To insulate a tank at the lowest possible cost, 6 inches of dry excelsior, shavings, or sawdust, tightly packed on the sides, bottom, and cover of the tank, will serve the purpose if kept dry.

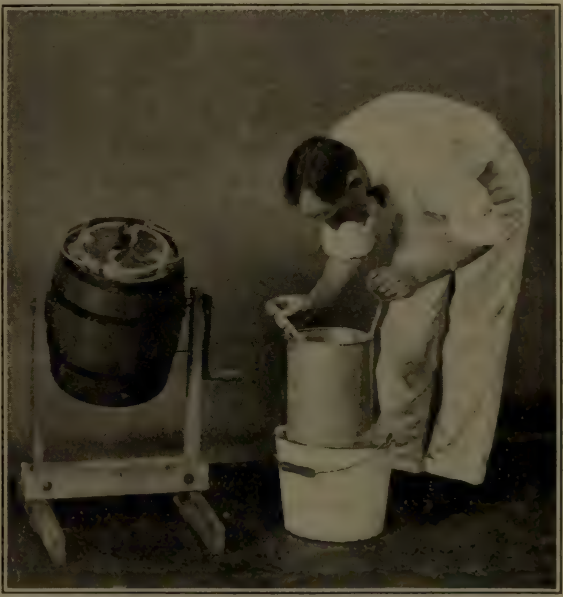

FIG. 1.—Cooling or warming the cream to the proper churning temperature.

RIPENING THE CREAM.

On many farms it is customary to churn only two or three times a week. Where this is the case the cream from each separation should be kept in the cooling tank until about 12 hours before churning. In order that the cream may ripen uniformly, it should be placed in one receptacle, thoroughly mixed, and warmed slowly to a temperature of from 65° to 75° F. Frequent stirrings with the stirring rod and the use of a thermometer are necessary to insure uniform and proper temperature throughout. Fresh cream should not be added after ripening has begun. The cream should be allowed to stand at the ripening temperature (from 65° to 75° F.) until it thickens, assumes a glossy appearance, and is mildly sour, when it should be cooled quickly to churning temperature or below. (The churning temperature is usually from 52° to 60° F. in the summer and 58° to 66° F. in the winter.) This cooling may be done if the cream is in a can by placing it in the cooling tank and stirring it occasionally. Ice or cold water should never be put into the cream. In order that the butter may have the desired firmness of body, the cream should be held at churning temperature or slightly below for at least two hours before it is churned. Even after it is cooled the cream will continue to sour somewhat, but when ready for churning it should still be only mildly sour, not to exceed 0.6 per cent acidity, as determined by the acidity test.

Special care should be taken to prevent the cream from becoming too sour, which has two harmful results—it gives the butter a sour, overripe cream flavor and injuries its keeping properties.

The souring of cream is caused by the growth of bacteria, which are a simple form of plant life. Some bacteria produce lactic acid and, as a by-product, the flavors that are desirable in butter. Many other types of bacteria, however, grow and produce bad flavors at the temperature used for ripening cream. If the milk or cream has been contaminated by unclean methods during milking or by utensils that have not been properly cleaned and sterilized, "off flavors" will develop in the cream during ripening and will be retained in the butter. Undesirable flavors may be developed even in clean cream if the ripening temperature is too high or too low or if the cream becomes overripe; in fact, an overripe cream flavor is one of the most common defects in farm butter.

The organisms that develop the desirable lactic acid and its attendant flavors in the cream are very susceptible to the influence of temperature. Although they grow and produce acid in a very wide range of temperature, the flavors that are desired in butter are produced only within a very narrow range. It is therefore very essential to use an accurate thermometer and to control the ripening temperature carefully. Lactic-acid bacteria are more active in summer than in winter, and for that reason, together with the fact that the temperature of the cream during ripening is usually affected somewhat by the atmospheric temperature, it is well to begin the ripening process at a higher temperature in winter than in summer. Experience will demonstrate just how to handle the cream so that it will be in the proper condition when it is desired to churn.

STARTERS.

In creameries it is customary to control to some extent the ripening of cream by means of "starters," which are pure cultures of lactic-acid-producing bacteria grown in pasteurized milk. The making of starters is technical work that should not be undertaken unless butter is made on a commercial scale. If the milk and cream are produced under proper conditions, there is no need for using starters. If handled under those conditions and protected from contamination, cream will develop the desired flavor when allowed to ripen or sour naturally at the proper temperatures.

When butter is made on a commercial scale, it may be advisable to control the ripening and thus make a product that is more uniform from week to week.

Commercial cultures for starter making may be obtained from culture manufacturers and from dairy-supply houses. Directions for using accompany each package and should be followed carefully.

A natural or homemade starter may be made as follows:

1. Clean thoroughly and boil for five minutes three pint fruit jars and tops. After boiling, keep the jars covered to prevent the entrance of bacteria.

2. Take a pint sample of milk freshly drawn from each of three cows, place in the jars, cover, cool to 75° F., and keep at that temperature until curdling occurs.

3. Curdling, or coagulation, should take place in about 24 hours. An ideal curd should be firm, smooth, marblelike, free from holes or gas bubbles, and should show little or no separation of the whey. It should have a clean, sharp, sour or acid flavor.

4. Select the sample that most closely meets those conditions and propagate it, discarding the others. The selected sample is propagated as follows:

(*a*) Clean thoroughly and boil for five minutes a quart jar, the top, and a teaspoon.

(*b*) Fill the jar with freshly drawn milk, cover loosely, heat slowly to boiling, and pasteurize by boiling gently for 30 minutes.

(*c*) Cool the milk to 75° F. and add a teaspoonful of curdled milk described in section 3 and set away to curdle at that temperature.

(*d*) Propagate the starter from day to day in the same manner described in (*a*), (*b*), and (*c*). The starter described in (*c*) is the one to use for ripening the cream, and should be added in such quantities as to be one-tenth to one-fifth of the cream to be churned. Starter is put into the cream while the latter is being warmed to the ripening temperature. The ripening process with starter is exactly the same as natural souring except that it takes place in a shorter time.

THE PROCESS OF CHURNING.

THE PROPER TEMPERATURE.

The desirable temperature at which to churn is that which makes the butter granules firm without being hard. This is usually obtained under normal conditions when the churning occupies 30 or 40 minutes. The churning temperature necessary depends upon the season of the year and certain other factors, but is usually from 52° to 60° F. in the summer and from 58° to 66° F. in the winter. If the cream is churned at 62° F. in winter, and the butter comes in 35 minutes, with the granules firm, it will be noticed, as summer approaches and the cows are turned out to pasture, that the cream churns more quickly and the butter is softer. This is an indication that a lower churning temperature should be used, and thus from season to season the churning temperature is regulated so that the butter granules may have the proper firmness.

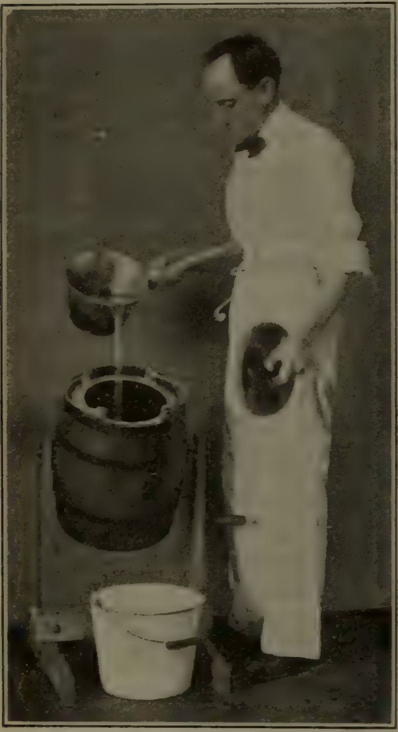

FIG. 2.—Preparing the churn.

When the temperature is either too low or too high, undesirable results are obtained. A low temperature prolongs the churning period unnecessarily, and may even make it impossible to churn butter. It causes the granules, especially when the cream is thin, to form in tiny pellets, like fine shot, many of which run out with the buttermilk. The working of the butter and the incorporation of the salt are accomplished only with great difficulty, and the body of the butter is liable to be brittle and tallowy. Adding hot water to cream to warm it, and using wash water more than 3 degrees warmer than the butter in order to soften it, are bad practices, since they injure the quality of the butter. If the proper churning temperature is used, the butter granules will be of the proper firmness.

Too high a churning temperature in churning is even more to be avoided, because it is directly responsible for the following undesirable results:

1. Loss of butterfat in the buttermilk. When the churning temperature is high enough to reduce the churning period to about 10 minutes, the loss of butterfat in the buttermilk may be as great as 1 or 2 per cent, whereas, under proper conditions, the loss usually does not exceed 0.2 per cent.

2. Injury to the quality of the butter.

(*a*) Too much buttermilk in the butter. When the butter granules are so soft that they do not remain distinct, but stick together in large masses, the washing out of the buttermilk is greatly interfered with and abnormally large quantities of it are incorporated into the butter. Butter of that kind has poor keeping qualities and quickly develops bad flavors. Other things being equal, the less buttermilk or curd in butter the better are its keeping qualities. The "off flavors" that so quickly develop in much of the farm-made butter are not produced by decomposition of the butterfat, but by decomposition of the milk solids which are found in the buttermilk. Because the drops of moisture expressed from the butter are milky in appearance, the butter is said to have a milky brine and for that reason is discriminated against.

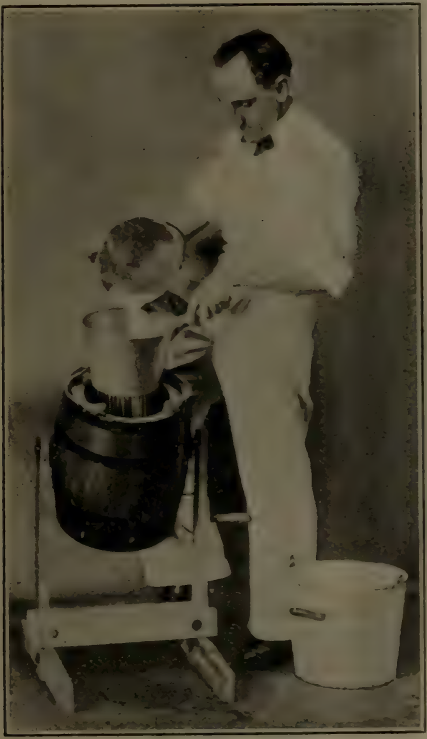

FIG. 3.—Straining cream into churn.

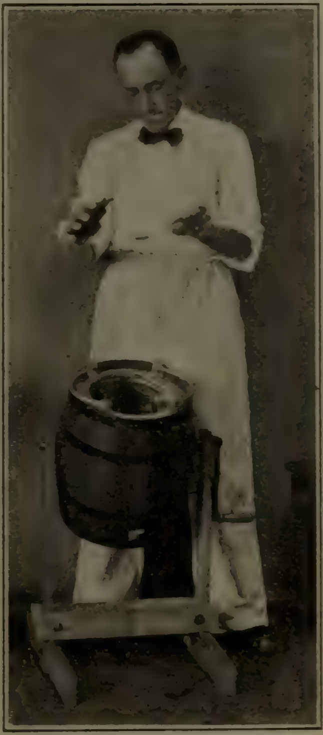

FIG. 4.—Adding butter color.

(*b*) "Leaky" butter and too much moisture. Butter that "comes soft" retains large quantities of moisture from the buttermilk and wash water. Because of the softness of the butter the moisture is not well incorporated, but is found in pockets and large drops. Upon the butter standing some of the moisture oozes out, or, when the butter is cut, large drops appear on the cut surface. Such butter is said to be "leaky." That fault is objectionable in itself and has the additional objection of causing a material shrinkage in the weight of the butter.

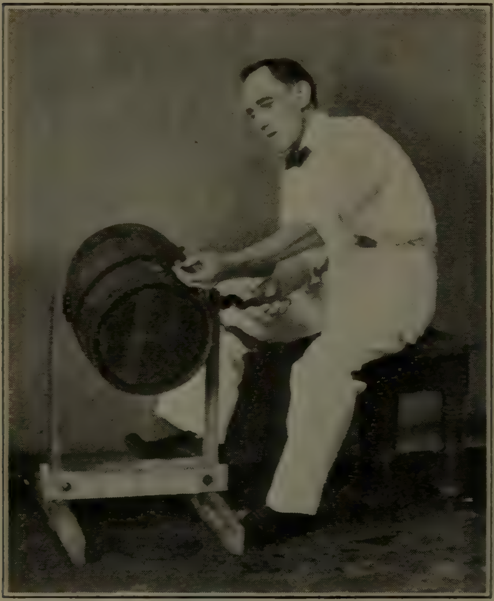

FIG. 5.—Allowing gas to escape.

(*c*) A weak, salvy body. Butter properly made has a firm, waxy body, but high temperatures during manufacture make it soft and of a salvy consistency. When eaten it seems to melt slowly and stick to the mouth, in contrast to the quickly melting and quickly disappearing butter with a firm, waxy body.

The use of the proper churning temperature is therefore essential to the production of first-class butter, which means that the churning period must occupy 30 or 40 minutes. There is no short cut in churning. Patent churns that churn butter in seven minutes produce practically the same harmful results as those just described.

PREPARING THE CHURN.

When cream is ready for churning the churn should be prepared. It should be cleaned thoroughly, rinsed with scalding water, then thoroughly rinsed and chilled with cold water.

The butter ladles, paddles, worker, and printer should be treated in the same way, and all but the worker placed in a pail of cold water until needed. If that is not done, the butter will stick to them.

PUTTING THE CREAM INTO THE CHURN.

Cream should be poured into the churn through a strainer to break up possible lumps and to remove curd particles and any foreign matter that may be in it. In order to have the necessary concussion the churn should be only about one-third full. If too full, the churning period is prolonged, and if the cream foams it nearly fills the churn and prevents concussion. In that case it is usually necessary to remove some of the cream in order to obtain butter in a reasonable time.

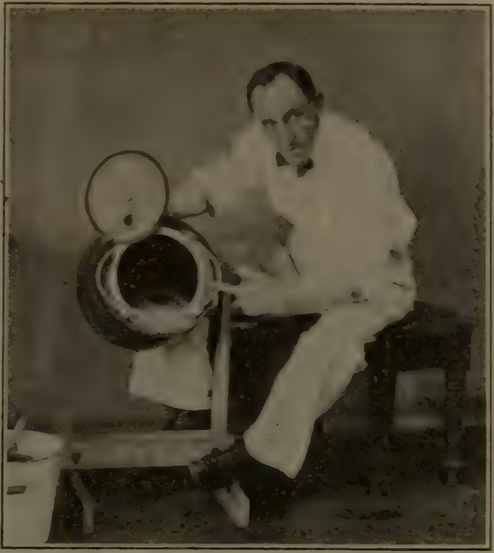

FIG. 6.—Churning completed. From 30 to 40 minutes of churning is usually necessary to obtain butter particles the size of wheat kernels.

ADDING BUTTER COLOR.

Except late in the spring and early in the summer, when butter has a naturally high color, a small quantity of butter color is usually added. In winter the quantity required to produce a shade of yellow like the desirable June color varies from about 20 to 35 drops per gallon of cream.

The color having been added to the cream, the churn may be started at a speed to produce the greatest concussion, which can be determined largely by the sound. About 60 revolutions a minute is the usual speed for the common barrel type of churn. After a few revolutions the churn should be stopped, bottom up, and the cork removed to permit the escape of gas. (See fig. 5.) This is repeated two or three times in the early stages of churning. At that period cream produces a very liquid sound, and the glass in the churn is evenly covered with cream.

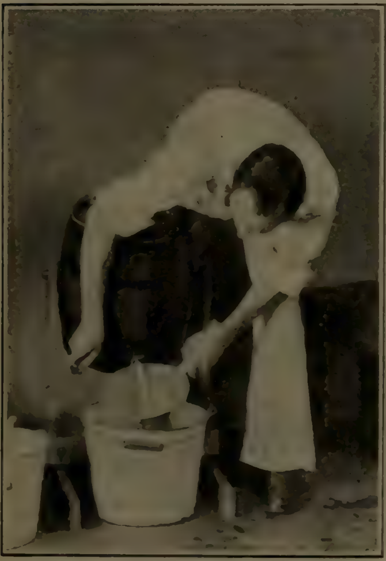

FIG. 7.—Drawing off the buttermilk.

When churning is nearly completed there is a noticeable difference in the sound made by the cream, while on the glass in the churn a thick, mushy mass will appear, which occasionally breaks away, leaving the glass clear. At this point the butter granules are just forming, and the cream is thick and finely granular, like yellow cornmeal mush, with buttermilk separating slightly from the tiny granules. The churn should be revolved several times, then stopped and the butter examined in order to prevent overchurning. When the granules are the size of grains of wheat the churning is completed. To continue the churning until the butter is in large masses is a bad practice, because it incorporates quantities of buttermilk which can not be washed out. The bad effect of too much buttermilk in the butter has been discussed already.

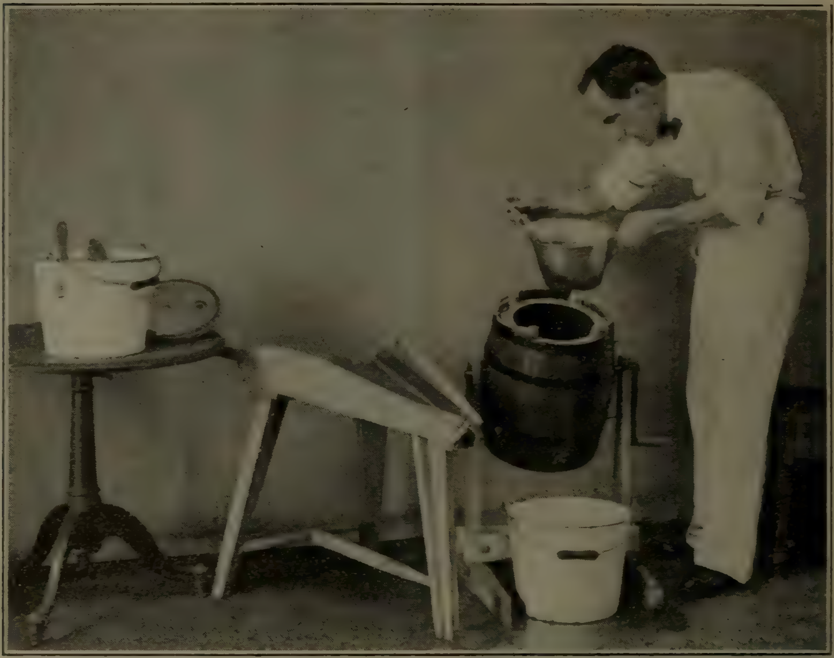

FIG. 8.—Taking temperature of wash water.

Churning completed, the buttermilk is drawn through the hole at the bottom of the churn and is run through a strainer to catch any particles of butter. (See fig. 7.)

WASHING, SALTING, AND WORKING THE BUTTER.

WASHING.

The object of washing butter is to remove the buttermilk. The only way that this can be done properly is to wash the butter when it is in small granules so that the largest possible surface is exposed to the water. To try to remove buttermilk by working it out of the butter is not effective; moreover, the excessive working injures the grain and body of the butter.

While the last of the buttermilk is draining off the wash water should be prepared. Only pure, clean wash water should be used, and it should be twice the quantity of and at about the same temperature as the buttermilk. The water should be placed in a pail or other receptacle and its temperature determined with a thermometer; if necessary it should be tempered by the addition of either warm water or ice. If the butter granules are too soft or too hard the temperature of the wash water may be either a few degrees warmer or colder than the buttermilk. Warm water has the same effect upon the body of the butter as high churning temperatures, whereas cold water makes the butter so hard that it can be worked only with great difficulty, and if very cold the proper incorporation of the salt is practically impossible.

After the buttermilk has been drawn off, the cork is replaced and one-half the wash water is poured into the churn. The cover of the churn is then replaced and the churn given about four rapid revolutions. The wash water is drawn off and the washing repeated. Two washings are usually sufficient, the second wash water when drawn off usually being almost perfectly clear.

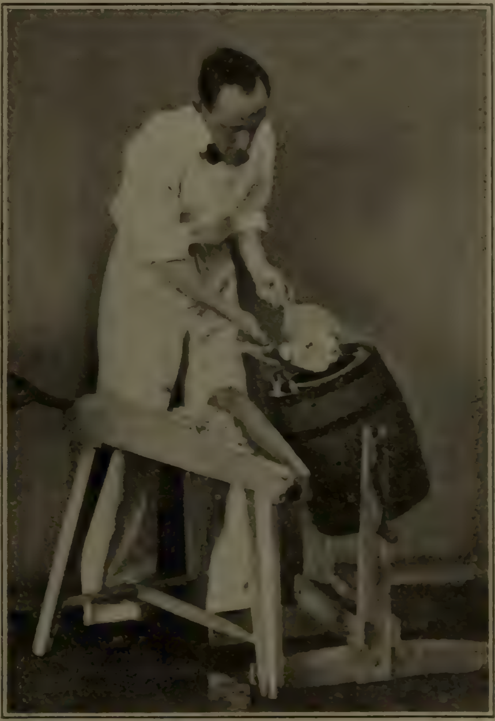

FIG. 9.—Removing the butter from the churn.

SALTING AND WORKING.

While the wash water is draining off the worker should be rinsed again with hot water followed by a thorough rinsing and cooling with cool water. This must be done immediately before using, because if the worker is slightly dry the butter will stick to it. The lever worker is widely used and gives satisfactory results, though other types do just as good work.

The butter, which is still in the granular condition, is removed from the churn with the ladle and placed in a convenient receptacle

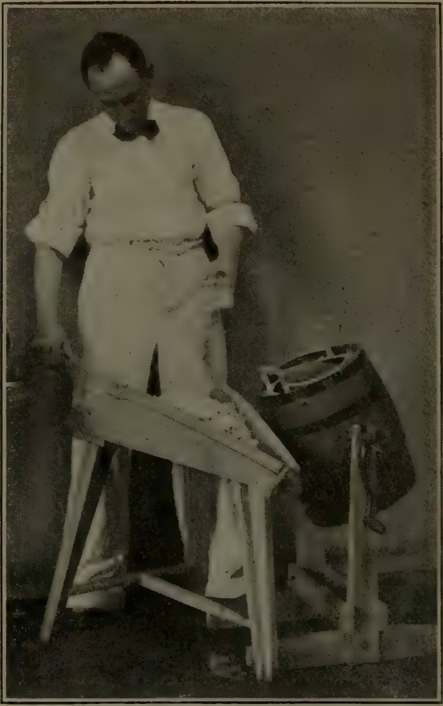

FIG. 10.—Salting the butter.

for weighing. The old-fashioned butter bowl is convenient, and this is the only use that should be made of it. The butter having been weighed the quantity of salt is calculated on the basis of three-fourths of an ounce for each pound of butter. The quantity may be varied to suit personal taste or the requirement of the market. The best grade of butter salt or table salt should be used. The butter is placed upon the worker, spread out about 2 inches thick, and the salt, free of lumps, sifted upon it. The butter is then pressed with the lever or other device, care being taken to press and not to rub or smear it. After being pressed into a thin layer it is folded upon itself into a pile and the pressing repeated. The working is continued until there is a thorough and even distribution of the salt and a desirable grain and body have been produced.

The working of the butter is a very important step in the making process and should receive careful attention. Too much working is a common fault in farm-made butter. Overworked butter has a sticky and salvy body, a dull, greasy appearance, and gummy grain. It feels warm in the mouth, sticks, and dissolves slowly. Properly worked butter has a waxy body and a bright appearance, and feels cool and dissolves quickly in the mouth. Butter has a proper grain if a

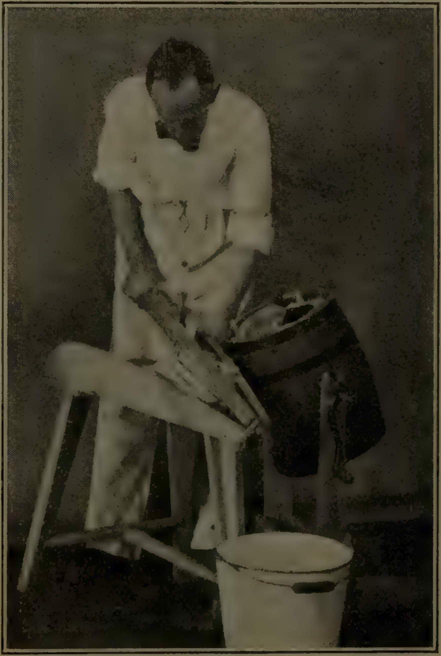

FIG. 11.—Working the butter.

slab breaks when bent at an angle of about 45 degrees and the broken surface has the appearance of broken steel. In addition, overworking butter injures its keeping properties.

When butter is underworked it is brittle, may be gritty because of undissolved salt, and, worst of all, may be mottled or uneven in color. The latter fault is common, and the purchaser who is not versed in butter making sometimes thinks it is due to mixing light- and deep-colored butter, and for that reason mottled butter is strongly discriminated against on the market. Mottles are caused by the uneven distribution of salt, the deeper-colored streaks or spots containing more salt than those of lighter color. To prevent that condition the butter must be worked until the salt is evenly distributed throughout the butter. When underworked, especially if highly salted, the butter is liable to be gritty because of undissolved salt. That fault will not occur in properly worked butter unless an excess of salt has been added. Butter that is cold and very firm requires more working than when it is comparatively soft.

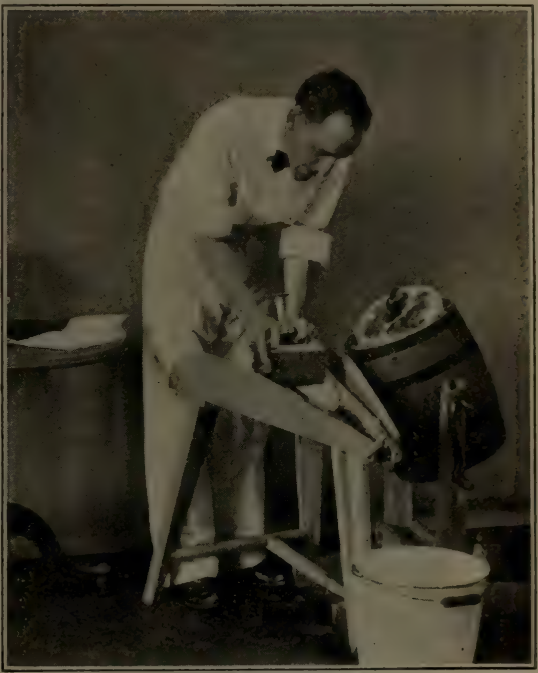

FIG. 12.—Printing butter.

BUTTER PACKAGES.

For home use butter is frequently packed into glazed earthenware crocks, which are very satisfactory and convenient receptacles for butter on the farm. If the glazing is imperfect, however, the crocks absorb butter and soon become very insanitary.

For market the rectangular 1-pound print is the most desirable form. It presents a more attractive appearance than the crock or "country roll," is more convenient and easily handled, and can be inserted into a carton which not only protects the butter but also adds greatly to the appearance of the package. To make prints, the printer is pressed upon the butter on the table until it is completely filled, the surplus is then scraped off with the paddle and the print

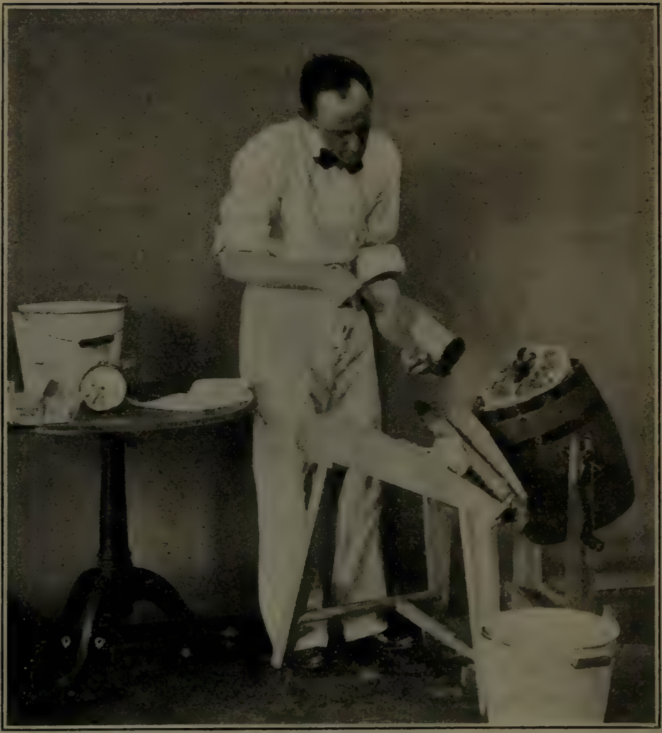

FIG. 13.—Leveling off the print.

pressed out on parchment wrapping paper. In order that the prints may weigh exactly a pound the printer should be carefully regulated and an occasional print weighed on an accurate scale. Prints for market should be wrapped in white parchment paper made for the purpose, 8 by 11 inches in size, and placed in paraffined cartons, upon which may appear the name of the farm or brand.

After printing and wrapping, the butter should be placed in a refrigerator or other cool place.

The churning utensils should then receive immediate attention. They should all be thoroughly cleaned by means of a hand brush, hot water, and dairy cleanser or washing powder, and thoroughly rinsed with boiling water. To place them in the sunshine or occasionally wash them with limewater aids in keeping them sweet.

DIFFICULT CHURNING.

The farm buttermaker sometimes fails to obtain butter after churning the usual length of time; in fact, the churning is sometimes prolonged for several hours without obtaining butter. The causes of the difficulty, together with the remedies, are as follows:

1. Churning temperature too low. It may be necessary, under exceptional conditions, to raise it to between 65° and 70° F.

2. Cream too thin or too rich. It should contain about 30 per cent butterfat.

3. Cream too sweet. If ripened to a moderate acidity it will churn more easily.

4. Churn too full. In order to obtain the maximum concussion the churn should be not more than one-third full.

5. Ropy fermentation of the cream preventing concussion. This may be prevented by sterilizing all the utensils and producing the milk and cream under the most sanitary conditions. If additional measures are needed, the pasteurization of the cream, with subsequent protection from contamination, and ripening it with a good starter, will be effective.

6. Individuality of the cow. The only remedy is to obtain cream from a cow recently fresh, or cream that is known to churn easily, and before ripening mix it with the cream that is difficult to churn.

7. The cow being far advanced in the period of lactation. The effects may be at least partially overcome by adding, before ripening, some cream from a cow that is not far advanced in the period of lactation.

8. Feeds that produce hard fat. Such feeds are cottonseed meal and timothy hay. Linseed meal, gluten feed, and succulent feeds such as silage and roots tend to overcome the condition.

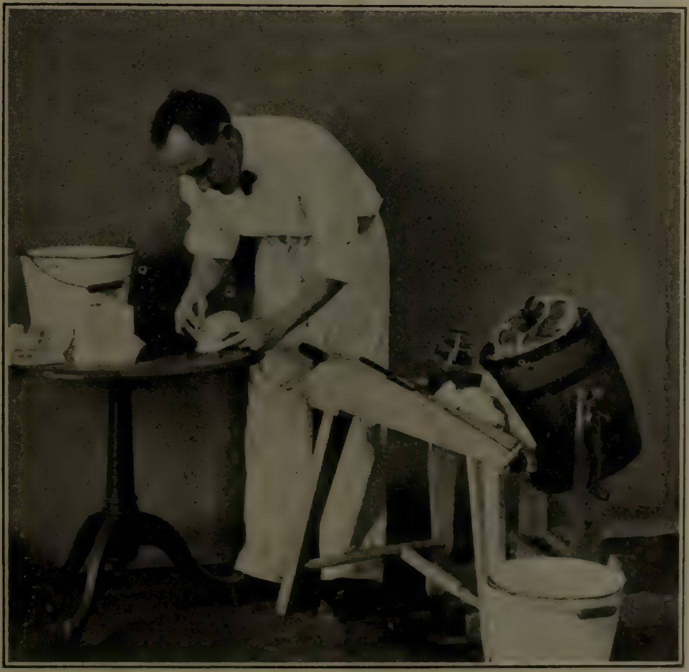

FIG. 14.—Wrapping print butter with parchment paper.

EQUIPMENT FOR FARM BUTTERMAKING.

The following equipment is needed for buttermaking on the farm:

1. *Milk pails.*—They should be of the type commonly known as covered-top, should be heavily tinned, and have all seams flushed with solder so that they can be cleaned easily.

2. *Cream separator.*—Any make is satisfactory if it skims clean and can be thoroughly cleaned and sterilized.

3. *Shotgun cans.*—As a cream container the style of can known as the "shotgun can" is much to be preferred to crocks and many other types of cans and pails commonly used. This can usually measures about 8½ inches in diameter and 20 inches high. One is shown in figure 1. These cans are easily handled, covered, and cleaned.

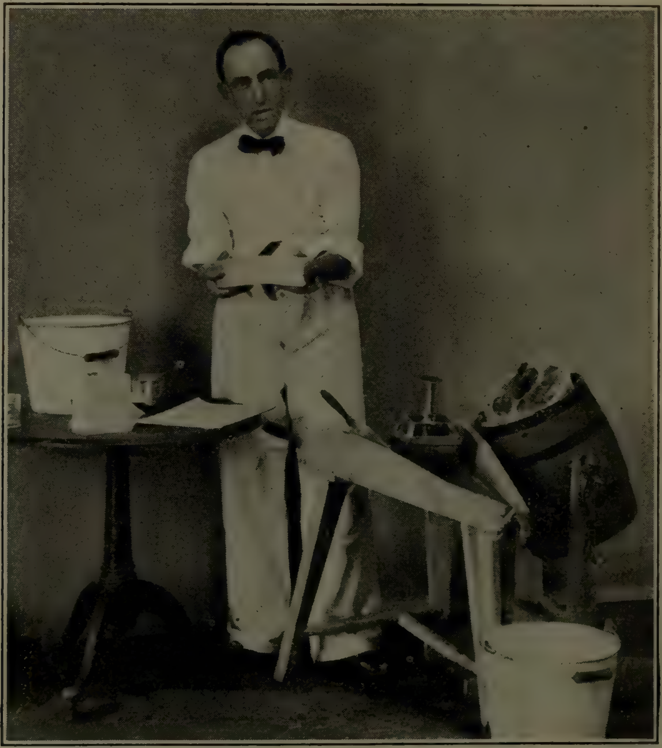

FIG. 15.—Inserting butter print in carton.

4. *Cream-cooling tank.*—Where there is an abundance of cold water any tank, properly used, will be effective. In very warm climates or where cold water can not be run through the tank several times daily, or where ice is used, it is advisable to use an insulated tank.

5. *Churn.*—The barrel type of churn (shown in several of the illustrations) is simple, inexpensive, easy to operate, and easily cleaned.

6. *Butterworker.*—The lever and the table butterworkers are very satisfactory. The former (fig. 11) is simpler and less expensive. When making large quantities of butter a table worker or combined churn and worker is frequently used.

7. *Thermometer.*—A floating dairy thermometer should be used.

8. *Cream and buttermilk strainer.*—A strainer similar to a colander or a strainer dipper is frequently used for straining both the cream and buttermilk. A hair sieve is sometimes used as a buttermilk strainer because butter does not stick to it as it does to tinware.

9. *Cream-stirring rod.*—A rod with a 4- or 5-inch disk on one end is more effective in stirring cream than a spoon or other implement. Stirring rods should be well tinned and smooth so that they may be cleaned easily.

10. Wooden paddle.
11. Wooden ladle.
12. Tin pails.
13. Half-gallon tin dipper.
14. Hand butter printer.
15. *Scrub brush.*—A stiff fiber brush is preferable to one with soft bristles.

PLAN OF DAIRY HOUSE.

A conveniently arranged dairy house is very desirable in making butter on the farm, especially if any considerable quantity is pro-

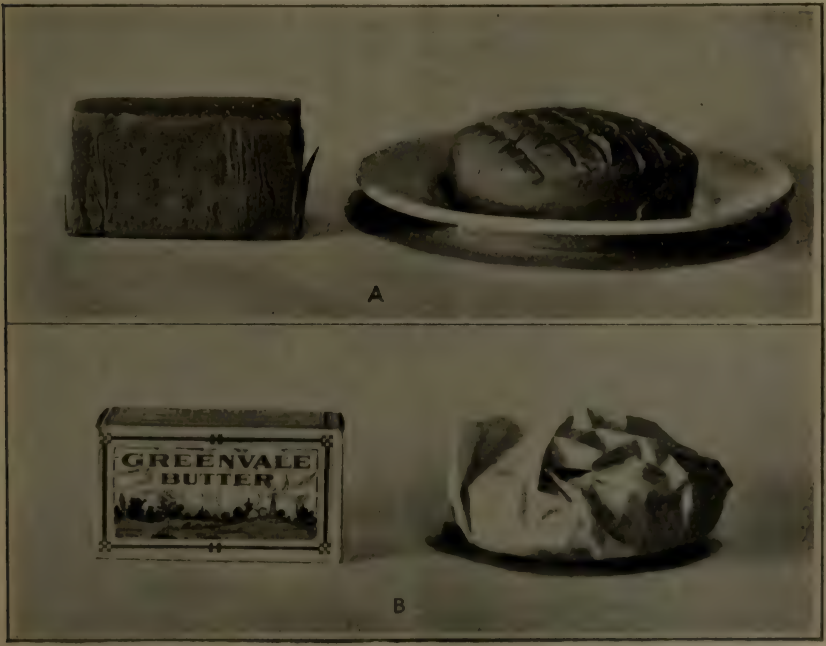

FIG. 16.—Comparison of the pound print and the country roll. The superiority of the former is obvious.

duced. A small, simple building will usually answer the purpose. A plan showing the principal features of such a house and a good arrangement of the equipment is shown in figure 18.

SUMMARY OF STEPS IN MAKING BUTTER ON THE FARM.

1. Produce clean milk and cream. Cool the cream immediately after it comes from the separator. Clean and sterilize all utensils.
2. Ripen the cream at from 65° to 75° F. until mildly sour. Always use a thermometer in order to know that the right temperature is reached.
3. Cool the cream to churning temperature or below, and hold at that temperature for at least two hours before churning.
4. Use a churning temperature—usually between 52° and 66° F.—that will require 30 or 40 minutes to obtain butter.
5. Clean and scald the churn, then half fill it with cold water and revolve until churn is thoroughly cooled, after which empty the water.
6. Pour the cream into the churn through a strainer.
7. Add butter color—from 20 to 35 drops to a gallon of cream—except late in the spring and early in the summer.
8. Put the cover on tight; revolve the churn several times; stop with bottom up, and remove stopper to permit escape of gas; repeat until no more gas forms.

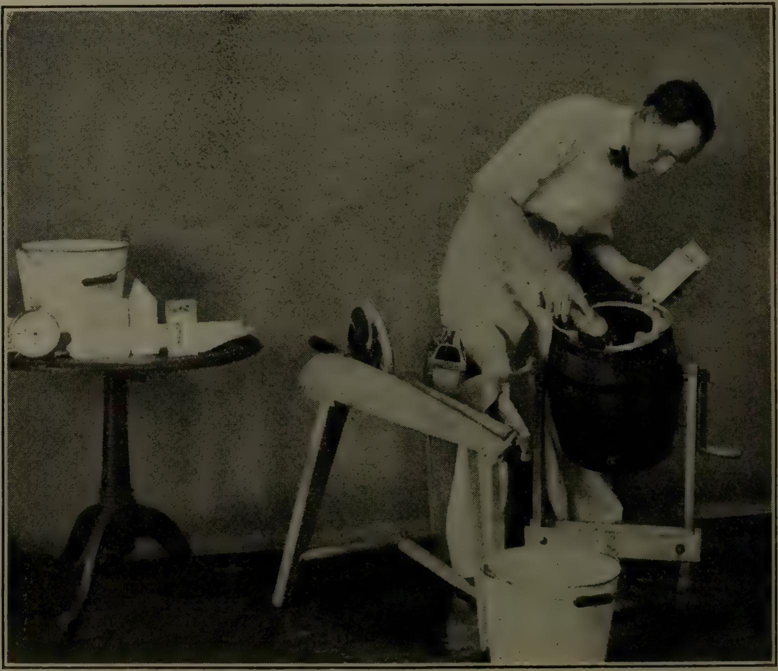

FIG. 17.—Washing butter utensils.

9. Continue churning until butter granules are formed the size of grains of wheat.

10. Draw off the buttermilk through the hole at the bottom of the churn, using a strainer to catch particles of butter. When the buttermilk has drained out, replace the cork.

11. Prepare twice as much wash water as there is buttermilk, and at about the same temperature. Use the thermometer; do not guess at temperatures. Put one-half the water into the churn with the butter.

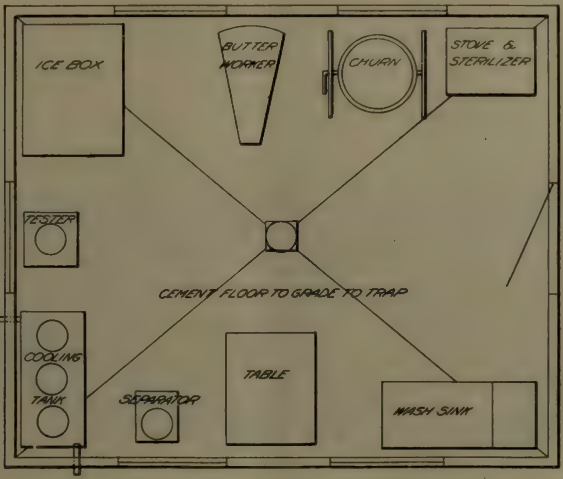

FIG. 18.—Plan of dairy house.

12. Replace the cover and revolve the churn rapidly a few times, then draw off the water. Repeat the washing with the remainder of the water.

13. The butter should still be in granular form when the washing is completed.

14. Weigh the butter.

15. Place the butter on the worker and add salt at the rate of three-quarters of an ounce to a pound of butter.

16. Work the butter until the salt is dissolved and evenly distributed. Do not overwork.

17. Pack in any convenient form for home use, or make into 1-pound prints for market, wrapping the butter in white parchment paper and inclosing in a paraffined carton.

18. Clean the churn and all buttermaking utensils.

HUMAN FOOD FROM AN ACRE OF STAPLE FARM PRODUCTS

MORTON O. COOPER and W. J. SPILLMAN

FARMERS' BULLETIN 877

UNITED STATES DEPARTMENT OF AGRICULTURE

OFFICE OF THE SECRETARY

Contribution from the Office of Farm Management

W. J. SPILLMAN, Chief

Washington, D. C. October, 1917

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1917

THIS bulletin is designed to give an acre-for-acre comparison of the food value of different crops and animal products. It shows that corn, on a given area, will produce more human food than any other crop commonly grown on American farms. This crop heads the list in units of energy produced per acre, and is ahead of all other crops except navy beans and soy beans in tissue-building material. In the latter element soy beans far outclass all other crops, showing nearly twice as much protein per acre as navy beans, which rank second in this regard.

It shows that the dairy cow is the most efficient of farm animals in the production of human food (milk) and that the hog is the most efficient in the conversion of grain into meat, producing five times as much per acre of crops as does any other animal.

The bulletin is not designed as a guide for the planning of farm operations; that is a matter to be determined by local environment, equipment, and general conditions.

HUMAN FOOD FROM AN ACRE OF STAPLE FARM PRODUCTS.

CONTENTS.

Page.
Food value of crops ... 6
    Corn ... 6
    The sweet potato ... 6
    The Irish potato ... 7
    Rye ... 7
    Wheat ... 7
    Rice ... 7
    The soy bean ... 7
    The peanut ... 8
    Oats ... 8
Page.

Food value of crops—Continued.

    The navy bean ... 8
    Cowpeas ... 9
    Buckwheat ... 9
Live-stock products ... 9
    Milk ... 9
    Cheese and butter ... 10
    Pork ... 10
    Other animals ... 10

THE present world shortage of food emphasizes as never before the importance, so far as is practicable, of making every acre of land produce a maximum quantity. Increasing the yield per acre by better tillage is a possibility, as is also increasing the acreage of land devoted to crops, and these possibilities should be realized to the fullest extent. Another important means of adding to the supply of human food is by giving increased attention to those crops which produce comparatively large amounts of human food per acre, and to those types of live stock which produce the most nutriment for man from a given quantity of feeding stuffs, always keeping in mind the proper rotation of crops and a well-balanced agriculture. That important additions can be made to the supply of human food in this manner is evident from a consideration of the facts presented in the accompanying table.[1] (See Table I.)

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[1] Although the information contained in these pages is too late to have any material effect on this year's production, it should be of value should the war be prolonged into next year. It is published now in order that whatever suggestive value it may have may be available in ample time for next season.

TABLE I.—*A comparison of the food produced annually by an acre of land when utilized in the production of various food crops and live-stock products.*

Food products.	Yield per acre.		Calories per pound.	Pounds protein per acre (digestible).	Calories per acre.
	Bushels.	Pounds.			
Food crops:					
Corn	35	1,960	1,594	147.0	3,124,240
Sweet potatoes	110	[a] 5,940	480	53.5	2,851,200
Irish potatoes	100	6,000	318	66.0	1,908,000
Rye	20	1,200	1,506	118.8	1,807,200
Wheat	20	1,200	1,490	110.4	1,788,000
Rice, unpolished	40	1,154	1,460	55.4	1,684,840
Rice, polished		1,086	1,456	50.0	1,581,216
Soy beans	16	960	1,598	294.7	1,534,000
Peanuts	34	524	2,416	126.2	1,265,018
Oats	35	[b] 784	1,600	89.4	1,254,400
Beans	14	840	1,337	157.9	1,123,080
Cowpeas	10	600	1,421	116.4	852,600
Buckwheat	24	[c] 600	1,252	34.5	751,800
Dairy products:					
Milk		2,190	325	72.3	711,750
Cheese		219	1,950	56.7	427,050
Butterfat		98.55	3,605	1.0	355,273
	Live (pounds).	Dressed (pounds).			
Meat:					
Pork	350	273	2,465	22.7	672,945
Mutton	205	113	1,215	14.7	137,295
Beef	216	125	1,040	18.5	130,000
Poultry: [d]					
Meat	103	66	1,045	12.7	68,970
	Dozen.	*Pounds.*			
Eggs	73.8	110.7	720	14.8	79,704
Total				27.5	148,674
	Live (pounds).	Dressed (pounds).			
For poultry meat alone	267	171	1,045	33.0	178,695
	Dozen.	*Pounds.*			
For eggs alone	122.4	183.6	720	24.6	132,192

[a] 54 pounds per bushel.

[b] Hulled kernels.

[c] Flour.

[d] The first section under "poultry" assumes that poultry are kept under ordinary poultry-farm conditions, the pullets being raised and the old hens and young males being used for meat. What eggs are not needed for hatching purposes are used for food.

The data for "poultry meat alone" assume the purchase of day-old chicks, which are grown to a 4-pound weight and utilized as food.

The data for "eggs alone" assume the purchase of hens and their utilization for the production of eggs alone.

The first section of Table I, relating to the product of an acre of the leading staple crops grown for human food, needs no explanation further than the statement that the calorie, or unit of heat energy, is the amount of heat required to raise the temperature of 1 kilogram (2.2 pounds) of water 1 centigrade degree (=1.8 Fahrenheit degrees). When food is assimilated it undergoes chemical changes in the body which render the energy it contains available for the production of heat and energy. The number of calories produced per acre is a measure of the relative value of the acre product for the production of heat and muscular energy.

The production of live-stock products per acre was arrived at by assuming the acre to be devoted to crops suitable for feeding the kind of animal under consideration and in the proper proportion to give a balanced ration. In cases where it is not practicable to do this because of the necessity of using some feed not produced on the farm, it is assumed that a suitable proportion of the acre product is exchanged for what else is needed.

In the case of hogs, the product of four-fifths of an acre of corn (28 bushels) and one-fifth of an acre of clover are assumed to constitute the feed used. When fed to hogs in this proportion a bushel of corn and the amount of clover consumed with it will make 12½ pounds growth. (See various experiment-station reports.) An acre utilized in this manner will thus produce 350 pounds of increase in live weight in hogs.

In determining the mutton produced on an acre, it was assumed that 0.65 acre of corn, grain (22.75 bushels) and stover, and 0.35 acre of clover (1,050 pounds of clover hay) are fed. A bushel of corn and the accompanying stover and clover hay fed in this proportion to yearling sheep makes, on the average, about 9 pounds of increase in live weight. An acre will thus produce 22.75×9=205 pounds. If the producer uses other feeds than those given in this example he will, of course, calculate their value in terms of corn, stover, clover, etc.

For beef cattle it was assumed that the acre is devoted to feed crops as follows: Corn for grain and stover, 0.80 acre; corn for silage, 0.12 acre; clover hay, 0.08 acre. It was further assumed that one-eighth of the corn thus produced (196 pounds) is exchanged for 146 pounds of cottonseed meal. The above feeding stuffs will feed a good steer 87.7 days a ration consisting of corn 15.64 pounds, cottonseed meal 1.66 pounds, silage 20.5 pounds, clover hay 2.74 pounds, and corn stover 7.29 pounds, allowing for a wastage of two-thirds of the stover as inedible. On such a ration a steer gains on the average about 2½ pounds a day. The entire acre thus produces a gain of 219 pounds live weight.

For the production of dairy products the acre was subdivided as follows: Corn for grain and stover, 0.50 acre; corn for silage, 0.25 acre; clover hay, 0.25 acre. This gives 960 pounds of corn (grain), 1,200 pounds of stover, 750 pounds of clover hay, and 3,760 pounds of silage, which is sufficient to feed a cow giving 6,500 pounds of 4½ per cent milk for 119.2 days, during which time she should give 2,190 pounds of milk.

Ten pounds of milk was assumed to make a pound of cheese. The amount of butterfat in 2,190 pounds of 4 per cent milk is 98.55 pounds. As in the case of beef cattle, there is considerable surplus of stover.

In the case of poultry it was assumed that the ration is made up of corn 34 per cent, wheat 56 per cent, and miscellaneous feeds 10 per cent. One-tenth of the acre was reserved for raising the miscellaneous feeds or products that could be exchanged for them. The remainder of the acre was assumed to be devoted to corn and wheat in proportions suitable for the production of these grains in the proportions stated, or 0.24 acre of corn and 0.66 acre of wheat.

FOOD VALUE OF CROPS.

Corn.—Table I shows that corn heads the list of crops commonly grown in this country. A 35-bushel crop of this cereal produces nearly 150 pounds of protein, or flesh-building material, and more than 3,000,000 units of energy. Wherever the conditions are favorable for extending the acreage of this crop it is evident that considerable addition can be made to the supply of human food by doing so. Millers should give special attention to the preparation of corn meal of good quality, and housewives should use increased quantities of this nutritious and palatable product as a substitute for other bread cereals. It is more practicable to increase the use of corn meal in this country than it is abroad, for our people are familiar with corn as a food, while most European peoples are not. We know how to prepare appetizing dishes from it, while they do not.

The sweet potato.—Sweet potatoes stand second in energy production, but are low in protein produced per acre The sweet potato is a southern crop, easily produced, but unfortunately a large percentage of the crop is not properly stored and as a consequence large quantities of potatoes are lost every year. However, by building storage houses and handling the potatoes as recommended in Farmers' Bulletin No. 548, the loss can be largely prevented. Growers who have good storage houses keep sweet protatoes throughout the winter for home use or for market. Our Southern States should grow an abundance of this crop, the consumption of which may be made to reduce the demand for bread cereals. Where facilities for canning sweet potatoes are available a portion of the crop preserved in this manner may be made available to parts of the country where the temperature drops so low as to make the shipping of fresh sweet potatoes a precarious undertaking, and the season of their use thus may be extended throughout the year. Sweet potatoes also may be dried successfully, and recent experiments show that meal made of dried sweet potatoes may be used with wheat flour in making bread.

The Irish potato.—The third crop on the list is the common Irish, or white, potato. This crop can be grown in all parts of the country. Its importance does not need emphasis here. During the continuance of the present emergency special effort should be made to produce all the potatoes that are needed.

Rye.—Rye stands next to corn in the list of cereal grains, being slightly more nutritious than wheat, but bread made from rye flour is not so acceptable to the American palate as bread made from wheat flour. It is only on sandy lands, which are better adapted to rye than wheat, and in other situations where rye is known to be a safer crop than wheat, that rye should have preference over wheat as a farm crop intended for human food.

Wheat.—Wheat stands second amongst the bread-making cereals in food produced per acre. Its wide climatic adaptability and the high degree of palatability of its products make it preeminently the bread crop of the world. In sections to which this crop is adapted it should be given precedence over all other crops except corn and potatoes (except on lands better adapted to rye than to wheat), remembering, of course, the necessity of maintaining a well-balanced agriculture.

Rice.—Rice stands very close to wheat in food produced per acre. It is probable that under present conditions a market could be found for a greatly increased output of rice. A considerable saving of valuable food could be made by marketing rice unpolished. The unpolished is much more palatable than the polished grain. If the unpolished rice were generally available, the American people probably would consume considerably larger quantities of this valuable cereal than at present.

The soy bean.—Soy beans lead all other crops in the production of digestible protein, exceeding corn in this respect by almost exactly 100 per cent. This crop deserves more attention in this country than it has yet received. There is no reasonable possibility of overplanting it. Soy-bean meal, the residue after the oil is expressed, can be mixed with wheat flour to the extent of 30 per cent without detriment to the palatability of the product, though the effect of such bread on the digestive tract is not yet known. Dry soy beans now are being used in considerable quantity as a substitute for navy beans in canneries, with excellent results. In addition, the soy bean is an excellent forage crop for cattle and hogs. Its use for this purpose greatly reduces the necessity for the use of grain and mill products in feeding these animals. The soy bean is a legume recently introduced into this country. It requires inoculation when grown on land new to it. Many farmers have failed in their first attempts to grow this crop because they overlooked this point. It is only a question of time and attention to detail when this difficulty will be entirely overcome. Soy beans, by using suitable varieties for seed, can be grown from southern Michigan to the Gulf coast. The Department of Agriculture will furnish free on application full instructions concerning the culture and management of soy beans. (Farmers' Bulletin No. 372.)

The peanut.—Peanuts are important from the standpoint of human food available from an acre for the reason that, besides being available as a catch crop in corn, they are gaining favor as a staple crop in the sandy lands of the cotton States, especially where the cotton-boll weevil is troublesome. In many sections alternate rows of corn and peanuts give good results, particularly on semiarid lands. In the southeastern States, from Virginia to Florida, peanuts have long been recognized as one of the chief crops for hog raising. The acreage for this and other purposes has increased greatly as hog raising has been introduced in the coastal-plain sections of the southeast.

The demand for peanuts has widened greatly as a result of new methods and the product now enters into two important avenues of commerce—(1) in the form of cake or meal, after the oil is extracted, as a valuable food for live stock, and (2) as a source of valuable fat for use for cooking and other purposes. A larger acreage of this crop is to be encouraged as a means of increasing the amount of pork products in the Southern States and to meet the demand for peanuts for the manufacture of peanut butter and for use in confectioneries. Recent experiments at the Texas experiment station demonstrate methods of feeding peanut meal or peanut cake to avoid the soft flesh in pork which ordinarily results from feeding the raw product. In addition to the nuts the hay is in great demand and it has a feeding value similar to that of alfalfa.

Oats.—Because of the relatively small amount of both protein and energy in oats, it is not believed advisable to increase greatly the acreage devoted to this crop, especially where the land can be devoted to other crops in the list given in Table I (except cowpeas).

The navy bean.—The bean crop is important as a source of protein. The navy bean produces only 36 per cent as much energy but more protein per acre than corn. It can be grown also in regions poorly adapted to corn. There has been a phenomenal increase in the acreage of beans this year, probably greater than conditions warrant. There is apparently no good reason for further extension of this acreage next year.

Cowpeas.—Although the cowpea crop is unimportant in the present connection, the fact that its seeds are highly palatable to most people and represent an important source of protein, as well as the further fact that it is widely grown in our Southern States as a catch crop in corn or after winter grain, justifies reference to it here. The South devotes its energies so largely to the production of one great money crop, cotton, that any readily available source of human food should not be overlooked in that section. Special effort should be made this year to save all the cowpea seed possible.

Buckwheat.—Buckwheat is important mainly because of the fact that it thrives on very poor land and can be planted very late in the season. The production per acre is large in comparison with that of other crops on poor land.

LIVE-STOCK PRODUCTS.

Table I further shows the amount of human food produced per acre when the land is devoted to the leading types of live-stock farming. The amounts produced are far smaller than in the case of most crop products available for direct use as human food. The justification for the use of land for live-stock farming, even under present emergency conditions, is twofold. In the first place, live-stock products add variety to the diet, and thus conduce to human vitality and efficiency. They contain relatively large numbers of elements which are necessary to the nutrition of the human body and which are found less commonly in vegetable products. Dairy products are especially important in the nutrition of children.

In the second place, many products of the farm are not directly usable as human food, but when fed to farm animals are converted into highly valuable nutritive substances. These products include corn stover, straw, hay, pasture grasses, and numerous waste products found on nearly all farms. Large quantities of by-products of certain manufacturing processes also are used as food for farm animals and thus converted into human food. Oil meal, gluten meal, and sugar-beet pulp are examples.

The necessity for variety in the human diet justifies the use of a certain amount of grain for stock feed, except in the most urgent extremity. Table I shows that the two types of live stock for which feeding grain is most justifiable are dairy cows and swine. An acre of land devoted to the support of either of these two classes of farm animals produces far more human food than is the case with any other class of live stock.

Milk.—Milk heads the list of live-stock products per acre as a source of both protein and energy. The wide range of nutritive substances contained in milk makes it by far the most important of our animal products. The cost of producing milk often can be lowered by increasing the amount of roughage and decreasing the amount of grain fed to dairy cows. This is especially the case where such roughage as silage, alfalfa, clover, or soy-bean hay is available.

Cheese and butter.—Next to milk and pork, more human food per acre can be produced in the form of cheese or butter than in any other animal product. Especially in those sections where alfalfa is the leading field crop, which is the case in many parts of the West, the production of maximum quantities of cheese and butter is highly desirable under present conditions.

Pork.—The hog is by far the most efficient of domestic animals in converting grain into meat. The product of an acre of land, when fed to hogs, produces five times as much meat as when fed to any other farm animal. Even these animals can be kept with relatively small expenditures of grain by making liberal use of such forage crops as alfalfa, clover, soy beans, rape, and various other kinds of pasture. A great gain also can be made by marketing hogs at lower weights than customary. Gains made below 200 pounds require much less grain than those above this weight. Hogs are also a valuable means of disposing of many kinds of waste on the farm, such as kitchen refuse, skim milk, whey, and defective fruits, vegetables, and grains.

The fact that colored laborers in the cotton fields of the South live largely on corn meal and pork products is of interest. The economic conditions of their existence require the greatest possible economy in food consumption. They have been driven by force of circumstances to subsist mainly on the crop producing the largest amount of human food per acre, and, for the sake of variety in diet, the most efficient food-producing animal available to them.

Other animals.—Table I shows that beef cattle, sheep, and poultry produce comparatively small quantities of human food from a given area of land. Cattle and sheep can be maintained largely on cornstalks, straw, defective or otherwise cheap hay, waste-land pastures, weeds, and the like. These animals should be kept at least in sufficient quantity to prevent waste of such materials.

Although poultry produce relatively little human food from a given area of land, a small number of fowls can be maintained on farm wastes more largely than is the case with any other farm animal. They consume scraps from the kitchen, waste grain about the feed lots, weed seeds, insects, etc. A sufficient number of them should be kept on every farm to utilize all such materials to the fullest possible extent.

PUBLICATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE RELATING TO FOOD PRODUCTION.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Cereal Breakfast Foods. (Farmers' Bulletin 249.)
Beans. (Farmers' Bulletin 289.)
Potatoes and Other Root Crops as Food. (Farmers' Bulletin 295.)
Food Value of Corn and Corn Products. (Farmers' Bulletin 298.)
Cowpeas. (Farmers' Bulletin 318.)
Sweet Potatoes. (Farmers' Bulletin 324.)
Use of Milk as Food. (Farmers' Bulletin 363.)
Soy Beans. (Farmers' Bulletin 372.)
Mutton and Its Value in the Diet. (Farmer's Bulletin 526.)
How to Grow an Acre of Corn. (Farmers' Bulletin 537.)
Kafir as a Grain crop. (Farmers' Bulletin 552.)
Use of Corn, Kafir, and Cowpeas in the Home. (Farmers' Bulletin 559.)
Beef Production in the South. (Farmers' Bulletin 580.)
Cereal Crops in the Panhandle of Texas. (Farmers' Bulletin 738.)
How to Select Foods: I. What the Body Needs. (Farmers' Bulletin 808.)
Production of Baby Beef. (Farmers' Bulletin 811.)
How to Select Foods: II. Cereal Foods. (Farmers' Bulletin 817.)
How to Select Foods: III. Foods Rich in Protein. (Farmers' Bulletin 824.)
Fresh Fruits and Vegetables as Conservers of Other Staple Foods. (Farmers' Bulletin 871.)
Farm Management Practice of Chester County, Pennsylvania (Department Bulletin 341.)
Live Stock, 1914, and Census Data. (Separate 656 from Yearbook. 1914.)
Statistics of Grain Crops, 1915. (Separate 682 from Yearbook. 1915.)
Statistics of Crops Other than Grain Crops, 1915. (Separate 683 from Yearbook. 1915.)
Live Stock, 1915, and Miscellaneous Data. (Separate 684 from Yearbook. 1915.)
Statistics of Grain Crops. (Separate 719 from Yearbook. 1916.)
Statistics of Crops Other Than Grain. (Separate 720 from Yearbook. 1916.)
Live Stock, 1916, and Miscellaneous Data. (Separate 721 from Yearbook. 1916.)

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Beans, Peas, and Other Legumes as Food. (Farmers' Bulletin 121.) Price, 5 cents.
Principles of Nutrition and Nutritive Value of Food. (Farmers' Bulletin 142.) Price, 5 cents.
Poultry as Food. (Farmers' Bulletin 182.) Price. 5 cents.
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Value to Farm Families of Food. Fuel, and Use of House. (Department Bulletin 410.) Price, 10 cents.
Course in Use and Preparation of Vegetable Foods for Movable and Correspondence Schools of Agriculture. (Office of Experiment Stations Bulletin 245.) Price, 10 cents.
Some American Vegetable Food Oils. (Separate 691 from Yearbook. 1916.) Price, 5 cents.

GRAINS FOR WESTERN NORTH AND SOUTH DAKOTA

F. RAY BABCOCK, JOHN H. MARTIN
and RALPH W. SMITH
Scientific Assistants in Cereal Investigations

FARMERS' BULLETIN 878

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. October, 1917

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GOVERNMENT PRINTING OFFICE : 1917

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THE PRODUCTION of the small grains in western North and South Dakota and eastern Montana is most profitable when combined with live-stock farming and the growing of cultivated crops.

Spring wheat, oats, barley, and flax are the best small-grain crops to grow in this section, except that winter wheat generally yields better than spring wheat in the vicinity of the Black Hills. Wheat and flax may be grown as cash crops for market, while oats and barley may be marketed or fed to live stock. Winter rye, spring emmer, and millet also may be grown.

Plow old land in the fall and leave it rough over winter or plow it in the spring. Fall plowing, however, permits earlier seeding in the spring. Land on which a cultivated crop was grown the previous year need not be plowed. Prepare a good seed bed in spring with the disk and spike-tooth harrows.

Sow spring wheat and oats as early as the land can be put in good condition, barley after wheat and oat seeding is finished, and flax about May 1. Sow winter wheat and winter rye in late August or early September in North Dakota, and in September or early October in South Dakota. Sow on corn stubble or summer-fallowed land.

The best rates of seeding are as follows: Spring wheat, 4 pecks per acre; winter wheat, 3 to 4 pecks per acre, oats and barley, 5 to 6 pecks per acre, and flax, 20 to 30 pounds per acre. The best varieties to grow are named on page 21.

GRAINS FOR WESTERN NORTH AND SOUTH DAKOTA.

CONTENTS.

Page.
Description of the section 3
Growing the grain crops 6
  Making a seed bed on breaking 6
  Making a seed bed on stubble or old land 7
  Summer fallow and cultivated crops 7
  Selection of seed 8
  Treating seed for disease 9
  Seeding 9
  Harvesting 9
Grain crops and varieties 10
  Wheat 10
  Rye, emmer, and spelt 15
  Oats 17
  Barley 18
  Flax 20
  Millet 21
Recommended varieties of small grains 21

DESCRIPTION OF THE SECTION.

THIS bulletin gives information regarding the best grains and the best methods of producing them in the western half of North and South Dakota (west of the one-hundredth meridian) and in the eastern fourth of Montana. The information is based largely on experiments conducted during the last 9 or 10 years at three stations—Williston and Dickinson, N. Dak., and Newell, S. Dak. (See fig. 1.) The crops considered are wheat, rye, emmer, spelt, oats, barley, flax, and proso millet.

TOPOGRAPHY.

The area north and east of the Missouri River varies from comparatively level land to sharply rolling hills of glacial origin. West of the Missouri River are gently rolling hills and flat-topped buttes, with small valleys between. A few districts, such as the Bad Lands along the Little Missouri River in western North Dakota and the Black Hills in extreme western South Dakota, are too rough for tillage but are adapted to ranching. Williston is 1,875 feet above sea level; Dickinson, 2,453 feet; and Newell, 2,900 feet. Figures 2 and 3 show views of the experimental plats at Dickinson and Williston and give a fairly good idea of the topography.

SOILS.

The soils of the entire section are fairly deep and are generally well supplied with plant food. In western North Dakota fine sandy loam is the prevailing type, clay in eastern Montana, and clay loam and gumbo in South Dakota. A large district of gumbo soil surrounds the Black Hills in South Dakota and extends east to the Missouri River.

CLIMATE.

Rainfall generally decreases to the westward in this area, while the temperature and evaporation gradually increase from the Canadian line southward.

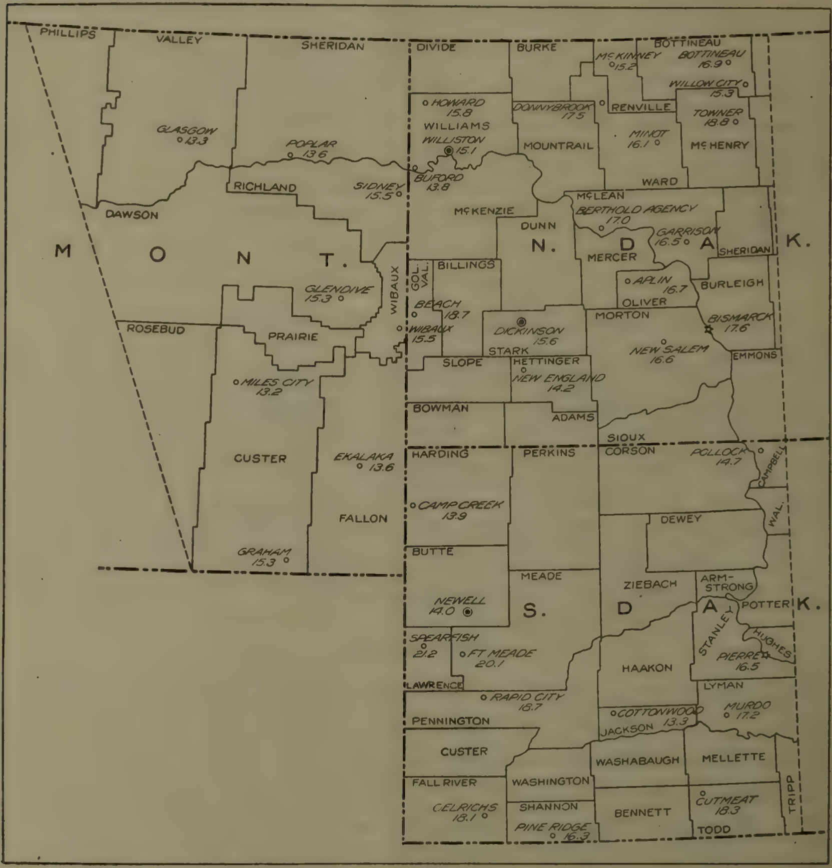

FIG. 1.—Map of western North and South Dakota and eastern Montana, the section to which this bulletin applies. The locations of the experiment farms at Williston and Dickinson, N. Dak., and Newell, S. Dak., are shown, with the rainfall at these points and at a number of others in the States named. The rainfall figures are averages for periods of varying length, most of them being for more than 10 years. These data are from the records of the Weather Bureau.

Rainfall.—The annual rainfall varies in general from 13 to 19 inches, though it reaches 21 inches in the Black Hills. The average rainfall of the different stations shown on the map (fig. 1) is about 16 inches.

More than half of the annual precipitation occurs during the four growing months of April, May, June, and July. The rainfall usually is sufficient to insure fair to good crops of grain. In occasional dry years the grain crop is a partial or complete failure, especially in western South Dakota.

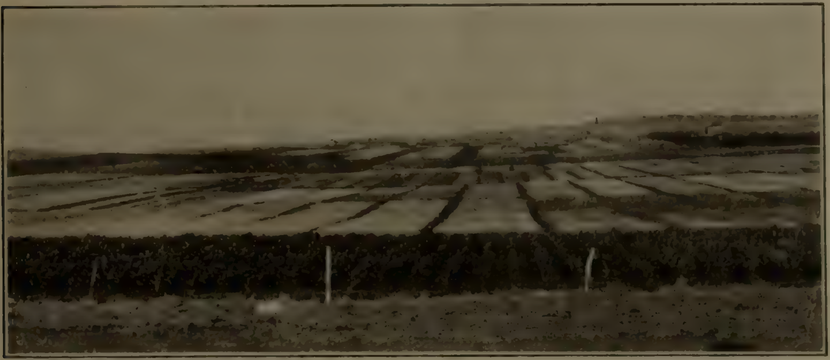

FIG. 2.—General view of the varietal plats of cereals at the Dickinson substation.

Evaporation.—In this section the evaporation is less than in the central and southern portions of the Great Plains area; hence less rain is required to produce a crop.

Temperature.—The mean annual temperature at both Williston and Dickinson is about 40° F. At Newell it is 44° F. The average frost-free periods at the three stations in the nine years from 1908 to 1916 are 108 days at Williston, 101 days at Dickinson, and 125 days at Newell. At Williston the average frost-free period for 35 years has been 119 days; at Dickinson, 109 days for 25 years.

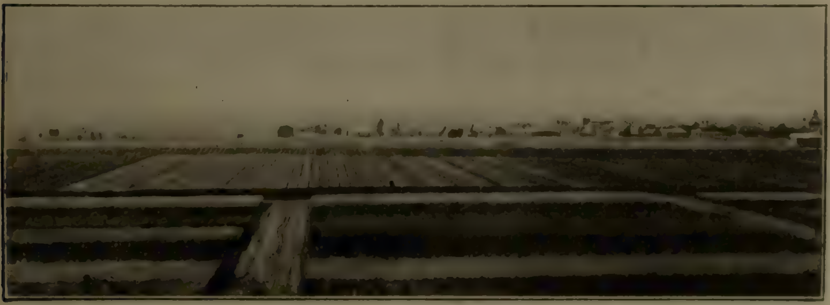

FIG. 3.—General view of the varietal plats of cereals at the Williston substation.

The growing season is long enough to insure good crops of spring grain. The winters usually are too severe for winter wheat in North Dakota and eastern Montana, but winter rye may be grown successfully. In districts near the Black Hills in western South Dakota winter wheat usually is successful.

FARMING CONDITIONS.

Most of the section discussed in this bulletin can not be irrigated; and, as the rainfall is comparatively low, dry-farming methods are practiced. Profitable crops of grain are usually grown in most of the section, but in the drier portions of western South Dakota grain crops are not always profitable in years of low rainfall. Live-stock production is the leading industry, and crop production is confined to the growing of grains and forage for feed. The growing of grain primarily for market is adapted only to those districts where good yields are assured, and even there it is best to combine grain farming with the production of live stock.

CROPS GROWN.

The leading crops are wheat, oats, barley, flax, rye, corn, alfalfa, and other forage crops. New settlers with little capital and few live stock usually raise wheat and flax, for which there is a ready market. As they increase their live stock, more oats, barley, corn, and alfalfa are needed.

DIVERSIFIED FARMING.

Only the small-grain crops are discussed in this bulletin. It is to be understood, however, that grain farming alone is not permanently profitable. It is better to combine live-stock production with it, growing corn, alfalfa, and other forage crops for feeding. Corn does well after small grain, and small grains do well after corn. The small grains also succeed after alfalfa and other forage crops, though it is best to grow a cultivated crop after alfalfa before sowing the small grains. Whatever system of farming is practiced, the grain crops have an important place in the crop rotation.

GROWING THE GRAIN CROPS.

The directions here given for growing grain crops are general, with modifications for differences in soil and climate. Owing to local variations these directions may not apply to all districts.

MAKING A SEED BED ON BREAKING.

The best time to break the native sod is in April, May, or June, because the soil usually is moist at that time. Late May or early June is considered best, as the grass then is young and succulent and decays readily. Later the sod may be dry, breaking with difficulty and decaying more slowly. Sod usually should be broken 4 or 5 inches deep. If the grass is thin and the sod light, deeper breaking is possible, especially with an engine. Pack the breaking with a roller or disk the day it is plowed, if possible. This closes up large air spaces and lessens the drying of the soil. Follow the roller immediately with the disk harrow and also with a spike-tooth harrow if spring grain is to be sown. Fresh breaking works up easily, but if not disked for a few days it dries rapidly, greatly increasing the work necessary to prepare a good seed bed.

If spring grain is to be grown on breaking, sow as soon as a good seed bed can be prepared. The practice of backsetting the breaking before sowing a crop usually is not profitable.

MAKING A SEED BED ON STUBBLE OR OLD LAND.

Old or stubble land should be plowed in the fall or early spring. Fall plowing is better than spring plowing, because it permits early seeding. So much better results are obtained from early than from late spring seeding that generally it is advisable to do as much fall plowing as possible. Sandy soils with a tendency to drift, as in the New Salem district of North Dakota, should be plowed only in the spring.

When land is fall plowed it should be left rough, to catch and hold the snow and to prevent soil blowing. Plow 6 to 8 inches deep if possible, covering all weeds and trash. Spring plowing may be slightly shallower than fall plowing. It should be worked immediately with the disk and spike-tooth harrows.

A good seed bed is firm underneath with 2 or 3 inches of loose soil on top. The surface mulch should not be too fine and powdery as blowing may result in some districts or rains may puddle it and then will not penetrate so readily. An excellent seed bed can be made in the spring on fall plowing or on spring plowing with the diately with the disk and spike-tooth harrows.

SUMMER FALLOW AND CULTIVATED CROPS.

Settlers in some sections practice summer fallowing to destroy weeds and hold soil moisture. On older farms, where more live stock is raised, corn usually is grown for feeding. The disked corn stubble is an excellent substitute for fallow as a preparation for spring grain. Fallow land produces no crop the year that it is fallowed, while if planted to corn from 2 to 4 tons of corn fodder to the acre may be grown, and in some years good yields of mature grain may be obtained. The corn crop requires but little more labor than the fallow. The small grains yield almost as well after corn as after fallow. Potatoes and other cultivated crops also are good substitutes for fallow in preparing the ground for small grain.

Where winter wheat is grown extensively, some fallowing may be advisable. One year of fallow and two or three years of cropping usually will be more profitable than alternate cropping and fallowing. In general, however, the increased production of live stock is recommended, with the growing of considerable corn and the use of disked corn stubble instead of fallow for spring grain.

Whenever summer fallowing seems necessary the ground should be plowed soon after the weeds start to grow, usually in June. Plowing may also be done in May or in the fall if other farm work permits. If it is not done till July, the weeds will have used much moisture. Plow the ground to a good depth. When the weeds start to grow again, cultivate with the spring-tooth disk or harrow often enough to keep them in check. Keep the weeds down, but do not pulverize the soil too finely.

In the Pacific Northwest, where fallowing has long been practiced, several forms of bar or knife weeders have been devised. These weeders probably can be used to advantage in controlling weeds on fallow in the Dakotas and Montana. The following discussion of weeders for fallow is from a recent bulletin on dry farming in southern Idaho.[1]

> The spike-tooth and disk harrows are effective weeders, but there are times when they can not and should not be used. The spike-tooth harrow is effective when the weeds are very small. The disk harrow is effective when the weeds are so well rooted that no other tool will kill them. Disking, however, is expensive and often pulverizes the soil more than is desirable. Various weeders, homemade and manufactured, are now in use. Many of them are cheap, effective, easily operated, and will cover a large acreage in a day.
>
> The "slicker," or knife weeder, is a tool 6 to 12 feet in length. One of the simpler forms is made by nailing boards or planks on top of three or four 2-inch by 8-inch sled runners 3 feet long, with a blade bolted under the middle or the rear end of the runners. This blade is made of a 3-inch iron bar half an inch in thickness and sharpened on the front edge. In the bar weeder, a round five-eighths-inch or three-fourths-inch rod is used instead of a blade. A 6-foot running board is nailed across the top in the middle of the machine and extends to the rear. The driver stands on this board and regulates the dip of the knife or bar by shifting his weight forward or backward. The blade is cleaned by lifting the rear end of the machine. The blade of the slicker should be made of the best steel and kept sharp.

SELECTION OF SEED.

It is advisable to sow good seed of varieties recommended by the nearest experiment station. After seed of a good variety has been obtained it pays to grow one's own seed. Home-grown seed, if of fair quality, is better than that obtained from a distance. Each farmer will do well to keep his seed as pure as possible and to select for seed a field that can be kept free from weeds and grain mixtures. If good seed is not available at home or in the locality, the nearest experiment station usually can supply it or tell where it can be obtained. Seed grain should be well cleaned by screening and blowing out light and diseased kernels and weed seed. It is much easier to remove weed seeds from seed grain than to destroy weeds in the field.

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[1] Aicher, L. C. Growing grain on southern Idaho dry farms. U. S. Dept. Agr., Farmers' Bul. 769, p. 9. 1916.

TREATING SEED FOR DISEASE.

The more common cereal diseases in western North and South Dakota and eastern Montana are rust and smut. Rust can not be prevented by seed treatment. Damage from rust can be partially avoided by early seeding, using early varieties or varieties that are somewhat rust resistant.

The covered smut of wheat and barley and the loose smut of oats can be fairly well controlled by the formaldehyde treatment, as follows:

Blow out with a fanning mill as many of the smut balls as possible, or remove them from the grain by other means. Mix 1 pound of common commercial formaldehyde with 45 gallons of water. Sprinkle the mixture over the grain spread several inches thick on a clean floor or canvas, stirring till every kernel is thoroughly wet. Cover the grain with a blanket for several hours, then spread it out to dry, stirring if necessary. If the smut balls are not removed before treating with the formaldehyde solution they may break later and again infect the seed, as they are not penetrated by the solution.

The grain may also be treated in sacks, putting about a bushel in each. Tie the sacks at the top, leaving room for the grain to swell. Put them into a barrel containing the solution, leaving the grain to soak about 10 minutes. It should then be taken out and dried. If the sacks are placed where the wind strikes them the grain may be dried in them. It must not be allowed to freeze while wet.

It is important to have the formaldehyde solution of the proper strength. If too strong it will delay or lessen the germination of the seed. If too weak it will not kill the smut spores. Before the seed is sown the drill should be washed out with the solution, to destroy any smut spores in it.[1]

SEEDING.

Rates and dates of seeding for each crop are discussed in the pages which follow. In general, spring grain should be sown as early in spring as the land can be put in good condition. Drilling is to be preferred to broadcast seeding, for drilled grain almost always yields better. The seed usually should be sown about 2 or 3 inches deep. The important thing is to get it into soil sufficiently moist to insure germination.

HARVESTING.

Most of the grain in western North and South Dakota and eastern Montana is cut with the binder and thrashed from the shock. Shock thrashing requires less labor than stacking and thrashing and is satisfactory when a thrashing machine can be obtained soon after harvest. If one has to wait long for a thrashing machine, the grain should be stacked. Stacking prevents injury from fall rains and clears the land for fall plowing. In addition the grain may be improved in quality by passing through the sweat in the stack.

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[1] For a complete discussion of grain smuts and their treatment, see Johnson, E. C. The smuts of wheat, oats, barley, and corn. U. S. Dept. Agr., Farmers' Bul. 507, 32 p., 11 fig. 1912.

Both the shocking and stacking of grain should be done carefully, to avoid injury from winds and wet weather.[1]

GRAIN CROPS AND VARIETIES.

WHEAT.

Wheat is the most important crop in the northern Great Plains. Spring wheat is commonly grown in the section here discussed, but winter wheat is important in the immediate vicinity of the Black Hills in South Dakota.

SPRING WHEAT.

The production of spring wheat in western North Dakota and eastern Montana is favored by climatic conditions and by the ready cash market for the crop. North Dakota alone produced over 150,000,000 bushels of spring wheat in 1915. It yields best in a rotation with corn and forage crops. With the increase of live stock and diversified farming in western North Dakota and eastern Montana spring wheat will continue to be the leading cash crop.

Spring wheat is grown also in western South Dakota, but in the drier localities the yields have not been sufficient to make it profitable. Spring wheat ripens later than winter wheat; hence it is more likely to be injured by rust and drought. Where winter wheat survives the winter in the vicinity of the Black Hills in South Dakota, it yields more than spring wheat.

The spring-wheat varieties adapted to western North and South Dakota and eastern Montana are all hard wheats. The two main divisions of hard spring wheat are the common and the durum.[2] The common wheats have rather long, slender heads, which may be either bearded or beardless. The durum (macaroni) wheats have broad, bearded heads with large, very hard kernels. The leading groups of spring common wheat are the Fife, Bluestem, and Preston (Velvet Chaff). Heads of representative varieties of these groups and of Turkey, the leading winter variety, are shown in figure 4.

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[1] For a more complete discussion of shocking and stacking grain, see Ball, C. R., and Clark, J. A., Growing hard spring wheat, U. S. Dept. Agr., Farmers' Bul. 678, 16 p., 4 fig. 1915.

[2] For a more complete discussion of spring wheat varieties, see Ball, C. R., and Clark, J. A., Varieties of hard spring wheat, U. S. Dept. Agr., Farmers' Bul. 680, 20 p., 7 fig. 1915.

The durum wheats are more rust resistant and usually more drought resistant than the common wheats. Occasionally, when hot, dry winds occur at blossoming time, the heads of durum wheat have failed to fill properly in some localities. When rust epidemics are severe, durum wheat usually produces fair yields, while common wheats often fail. The durums are more likely to lodge than the common wheats and for this reason sometimes require more labor in harvesting and thrashing. On the other hand, the durums do not shatter readily. Until recent years the market price of durum wheat was considerably below that of spring common wheat, but since 1912 the difference has been slight, the price of durum often being higher than that of similar grades of spring common wheat.

The relative yields of the leading varieties of each of the important groups of wheat at the Williston, Dickinson, and Belle Fourche (Newell, S. Dak.) stations are shown graphically in figure 5. In each case the yields are shown in percentages of the yield of the best durum wheat in the same period of years.

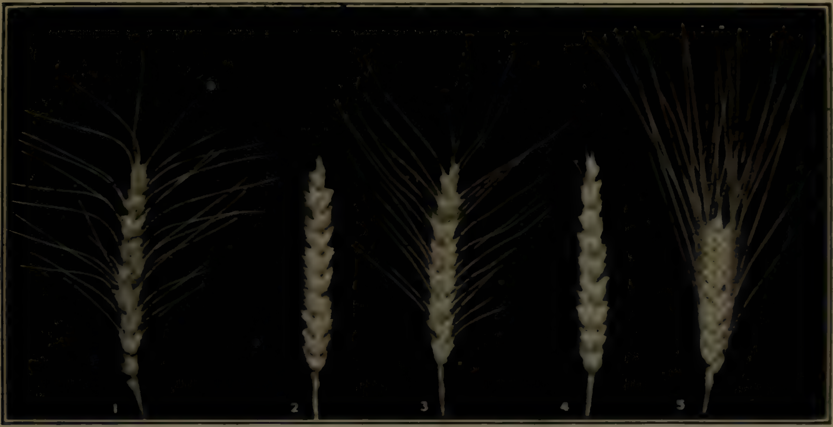

FIG. 4.—Representative heads of different types of wheat: 1, Turkey winter; 2, Fife; 3, Preston; 4, Bluestem; 5, durum.

At the Belle Fourche Experiment Farm during the nine years from 1908 to 1916, inclusive, the average yield of the best variety of durum wheat has been 2.5 bushels more than that of the best variety of spring common wheat. At Dickinson, N. Dak., the 10-year average yield is about 6 bushels in favor of the durum, while at Williston the durums have yielded somewhat more than the common wheats. The higher yields of durum in most of the section here discussed will offset a considerable difference in price. Because of the higher yields of durum wheats and their greater resistance to rust and drought, they should be more extensively grown in all parts of this section where spring wheat succeeds.

Of all the durum varieties tested at the three stations, the Kubanka, introduced into the United States from Russia in 1899 by Mr. M. A. Carleton, cerealist of the United States Department of Agriculture, has yielded best. It is recommended to all who wish to grow durum wheat in this section.

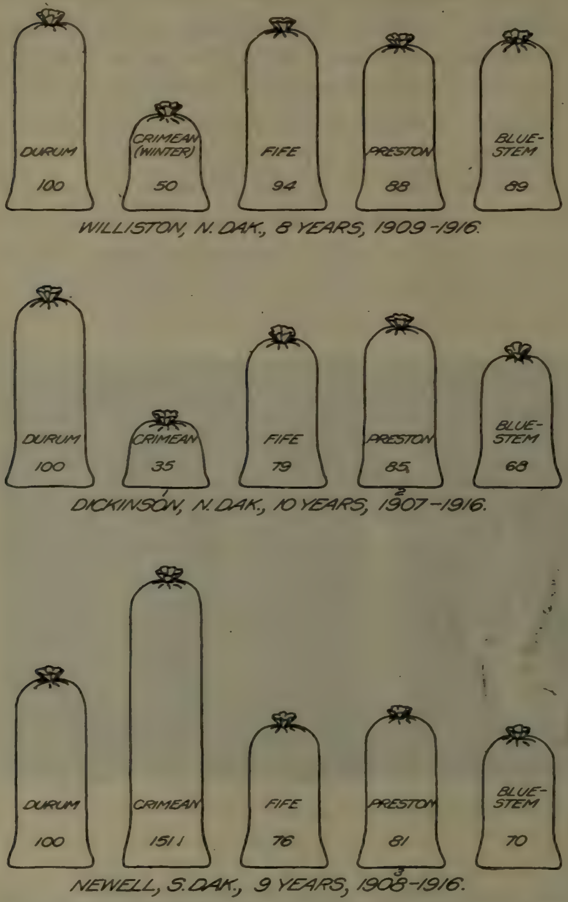

FIG. 5.—Average yields of the leading varieties of the principal groups of wheat grown on the three experiment farms at Williston and Dickinson, N. Dak., and Newell, S. Dak. The figures are percentages of the yield of Kubanka durum wheat, at each station. Figures from Williston are for 8 years, Dickinson 10 years, and Newell 9 years, except that (1) those for Crimean at Dickinson are for 4 years, (2) those for Preston at Dickinson are for 6 years, and (3) those for Prèston at Newell are for 7 years.

The Fife varieties of common wheat have yielded well in the section discussed in this bulletin. The Marquis has proved to be the best variety of Fife wheat for most of the section. It has been tested four years at all three stations. During that time it has been the highest yielding spring common wheat at Newell and Dickinson, and highest of all except Power Fife at Williston. The difference in yield between the Power Fife and Marquis at Williston is slight. The Marquis wheat was originated by the Canadian Department of Agriculture. It is similar in appearance to the other Fife varieties, but the straw, heads, and kernels are all shorter than those of typical Fife wheat, and it ripens several days earlier. Its earliness enables it to escape to some extent the effects of drought and rust. The short, stiff straw is not likely to lodge. The grain is held firmly by the chaff, so that it does not shatter readily, but on the other hand it thrashes with some difficulty. On farms in the vicinity of Williston the Marquis has sometimes been too short to harvest easily when sown on land cropped to small grain the previous year. In that district the Power Fife, which has longer straw, has given good results. In districts where the rust epidemic of 1916 was severe the Marquis yielded more than any other variety of Fife wheat.[1] The Marquis wheat is especially recommended for sowing on corn stubble, fallow, or rich land where other varieties are likely to lodge.

The Preston (Velvet Chaff) wheat is a bearded spring wheat, yielding less than the Marquis in most of the section under discussion. It is also of poorer milling quality.

Varieties of the Bluestem group usually yield less than the Fife wheats in this section. They shatter readily, and their lateness makes them more subject to injury by drought, rust, and frost. The Preston and Bluestem wheats are not recommended for western North and South Dakota and eastern Montana.

Early seeding of spring wheat is best. It should be sown as early as a good seed bed can be prepared. Late-sown grain is more likely to be injured by drought, rust, frost, and hail.

One bushel per acre is about the best rate at which to sow spring wheat, as shown by experiments at the three stations and the experience of farmers. In the drier sections or in very dry seasons thinner seeding may give slightly better results. Durum wheat has larger kernels and tillers less than common wheat; hence, usually it is sown at the rate of about 5 pecks per acre.

Spring wheat usually should be sown from 2 to 3 inches deep, to get it in moist soil. In heavy, wet soil, covering the seed from 1 to 2 inches will be sufficient.

WINTER WHEAT.

Where winter wheat is known to survice, as in the vicinity of the Black Hills and in a few other small districts in western South Dakota and southeastern Montana, it is more productive than spring wheat in most years. Winter wheat ripens earlier than spring wheat and is thus more likely to escape injury from drought and rust. At the Belle Fourche Experiment Farm, near Newell, S. Dak., the average yield of winter wheat in a period of nine years is 8 bushels per acre higher than the average yield of the best variety of spring wheat during the same years. In fact, winter wheat is perhaps the only grain crop which can be grown at a profit in the drier portions of western South Dakota. Outside of the Black Hills district of South Dakota, especially in North Dakota, winter wheat is winterkilled except during unusually mild winters or unless it is protected. The only successful method of growing winter wheat in these sections is by seeding in cornstalks or stubble which hold the snow and thus protect the wheat considerably. Even then winterkilling often is severe. At Dickinson, N. Dak., during the four years from 1913 to 1916, inclusive, the best spring wheat yielded 8.4 bushels more per acre annually than the best winter wheat. The winter wheat was protected by standing cornstalks. The acreage of winter wheat is increasing in western North Dakota, but because of the uncertainty of winter survival it can not be recommended there.

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[1] For a more complete description of Marquis and other spring wheat varieties, see the following:

Ball, C. R., and Clark, J. A. Marquis wheat. U. S. Dept. Agr., Farmers' Bul. 732, 7 p., 2 fig. 1916.

——— Varieties of hard spring wheat. U. S. Dept. Agr., Farmers' Bul. 680, 20 p., 7 fig. 1915.

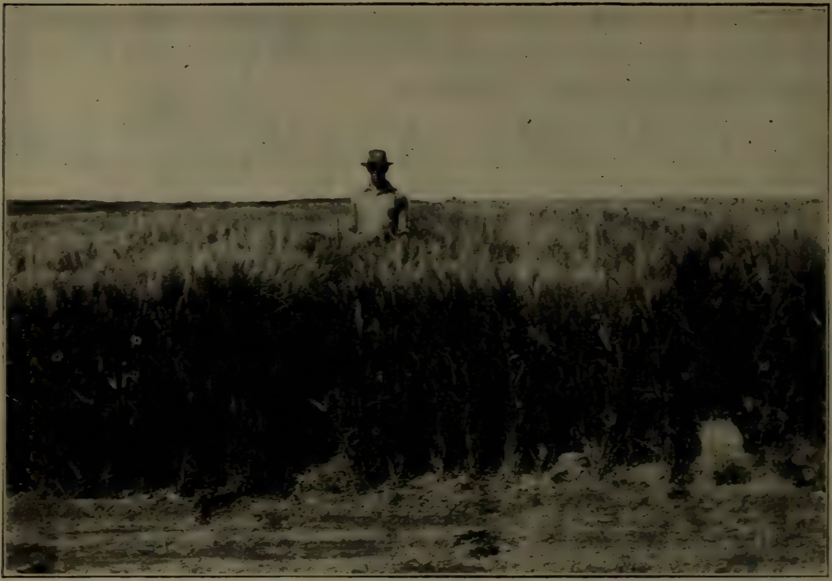

FIG. 6.—Plat of winter wheat on the Belle Fourche Experiment Farm, Newell, S. Dak., in 1915.

At Newell, S. Dak., winter wheat yielded best on fallowed land. A plat of winter wheat on fallow at Newell is shown in figure 6. The Kharkof winter wheat has averaged nearly 26 bushels per acre on fallow during the last nine years, which include two years of complete failure on account of drought. Good yields of winter wheat may be expected also when sown on corn ground. If winter wheat is badly winterkilled there is still an opportunity to sow some spring crop on the land, with no loss except the expense of seeding the winter wheat.

Tests of varieties of winter wheat have been conducted since 1908 on the Belle Fourche Experiment Farm at Newell, S. Dak. The Kharkof variety has yielded best during this period, though the average yield of the Turkey is only slightly lower. These varieties belong to the Crimean group of hard red winter wheat and are practically identical in appearance. The Kharkof wheat was imported by the United States Department of Agriculture from Kharkof, Russia, in 1900. The Turkey variety was first brought to this country from Crimea, in southern Russia, by the Mennonites in 1873. Little or no difference is apparent in either the yields or winter hardiness of these two varieties of winter wheat, and either of them may be grown. The beardless winter-wheat varieties have not yielded as well at Newell as the bearded varieties of the Crimean group.

The proper time to sow winter wheat varies from year to year. Experiments at Newell indicate that winter wheat should be sown before October 15. Seeding in September is usually safest. Late seeding of winter wheat is not recommended, although fair yields have been obtained from winter wheat which was sown in November and did not come up until April. Seeding before September 15 usually does not result in higher yields than seeding in early October. If the wheat plant reaches the second leaf stage it may survive the winter as well as if it had produced six or eight tillers. On fallowed land or corn ground it is advisable to sow winter wheat not later than October 1, even though the soil is dry. Except in 1911, the rainfall has been sufficient to bring up winter wheat in the fall each year since experiments were begun at Newell in 1907. Wheat comes up more quickly if sown before the fall rains than if seeded immediately after them. Land from which a crop has been harvested recently is often too dry to start the wheat in the fall. In North Dakota and eastern Montana it should be sown during the latter half of August or early in September.

Winter wheat should be seeded deep enough to get it into moist soil. The proper depth is about 2 or 3 inches, and seeding deeper than this is not advisable. If winter wheat is seeded too shallow, the surface soil may dry out before the seeds have sprouted.

Experiments at Newell show that winter wheat should be sown at the rate of 3 or 4 pecks per acre. If the seeding is late or the land is poorly prepared, 4 pecks per acre should be sown, but on fallowed land 3 pecks is enough, especially if the wheat is sown early. Seeding less than 3 pecks per acre has resulted in lower yields. The rate of seeding should be heavier than usual if the grains are swollen from the smut treatment or if the kernels are unusually large.

RYE, EMMER, AND SPELT.

RYE.

The acreage of winter rye in western North and South Dakota has increased rapidly during the last few years. Winter rye is much hardier than winter wheat. The hardy varieties of winter rye seldom winterkill when unprotected even in northern North Dakota. At Newell, S. Dak., winter rye has yielded less than winter wheat, but in North Dakota it has yielded considerably more. It is a valuable feed crop and there is also some demand for it on the market.

If sown early, winter rye may be pastured to some extent in the fall, and the vigorous growth in early spring supplies some spring pasturage. It is often used as a smother crop to keep weeds in check. It ripens earlier than any other grain crop in this section, which usually enables it to escape serious injury from drought. It also ripens earlier than wild oats, making it a desirable crop to grow on land infested with this and other noxious weeds. Much land in the Dakotas has become foul with wild oats through continuous grain growing, and winter rye is being used more and more as a crop to help rid the land of this pest.

In North Dakota and Montana the variety of winter rye known as North Dakota No. 959 should be grown. In western South Dakota either this variety or Swedish (Minnesota No. 2) is suitable. Spring rye is not widely grown in western North and South Dakota and does not yield as well as winter rye.

In western North Dakota and eastern Montana winter rye may be sown from August 15 to September 15. In South Dakota it should be sown not later than October 15. Early seeding is preferred, especially if it is desired to rid the land of weeds. When sown early the plants tiller more and less seed is required per acre. From 4 to 5 pecks per acre is the usual rate of seeding.

Winter rye is often sown in disked grain stubble, thus requiring little labor in preparing the soil. When stubble ground is too dry for the seed to germinate, it may be sown on corn land, on fallow, or on fall plowing.

EMMER AND SPELT.

Spring emmer, commonly but incorrectly called spelt or speltz, is grown to some extent as a feed crop in western North and South Dakota. The Yaroslav is the best variety of spring emmer for this region. Its yield in pounds per acre is about the same as that of oats or barley,[1] and its feeding value is about the same as that of oats. The Yaroslav emmer is fairly drought resistant and very rust resistant. Winter emmer is not hardy enough for the Dakotas.

Spring emmer should be sown early at the rate of about 6 pecks per acre.

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[1] At Williston, in an 8-year test, Yaroslav emmer yielded a little less in pounds per acre than the best varieties of oats and barley, while at Dickinson, in the same period, it yielded slightly more. At Newell the average yield of emmer is much lower than that of the best varieties of oats and barley.

OATS.

Oats can be recommended as a profitable feed crop for the northern Great Plains. Very satisfactory yields have been obtained in western North Dakota and eastern Montana. At the Belle Fourche Experiment Farm at Newell, S. Dak., oats have not yielded as much as wheat. In the drier portions of western South Dakota oats have not been profitable in years of low rainfall, and this crop is not recommended for growing there for market. It may continue to be grown to some extent for feed, however.

Drilling on disked corn ground is the best method of seeding oats.

The early yellow varieties, Sixty-Day and Kherson, have yielded best at Newell, S. Dak., and on dry land in Montana. The midseason white varieties have yielded best in western North Dakota. At Williston, the Abundance, Lincoln, and Early Mountain have yielded considerably more than the early varieties, ranking in the order named. At Dickinson, the Early Mountain, Abundance, Golden Rain,[1] and Victory have yielded a little more than the Kherson and Sixty-Day. The late varieties of side oats have not yielded well at any of the stations. The midseason varieties mentioned are recommended for western North Dakota and for northeastern Montana.

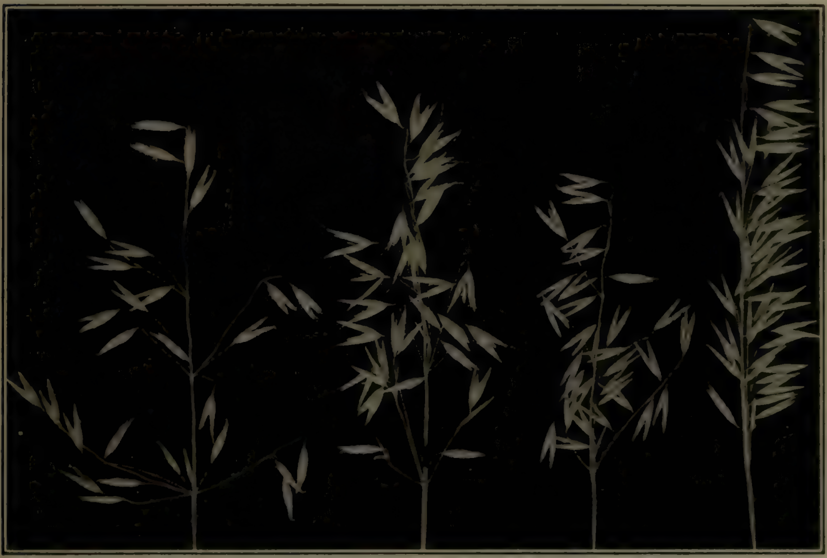

FIG. 7.—Heads of four varieties of oats grown at the Dickinson substation: From left to right—(1) Early Mountain, (2) Victory, (3) Kherson, and (4) White Russian.

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[1] The Golden Rain is a yellow midseason variety.

The early varieties, Sixty-Day and Kherson, are recommended for western South Dakota and the drier portions of eastern Montana and southwestern North Dakota. Heads of several representative varieties of oats are shown in figure 7.

The early yellow varieties, Sixty-Day and Kherson,[1] are very similar. Both have short, fine straw, suitable for hay, and small, thin-hulled, slender kernels. The midseason varieties have taller, coarser straw and larger, plumper grains, with usually a higher weight per bushel.

Early seeding is best with oats as well as with spring wheat. Sow as soon after sowing spring wheat as a good seed bed can be prepared.

Experiments with different rates of seeding oats have not shown much difference in average yields. Midseason varieties in North Dakota should be sown at the rate of about 6 pecks per acre. In South Dakota and Montana the early, small-kerneled varieties may be sown thinner with as good results. Sow from 2 to 3 inches deep.

BARLEY.

The acreage of barley is increasing rapidly in western North Dakota and eastern Montana. Barley is a good feed crop for all classes of farm animals and should be grown more generally. At Williston and Dickinson the 9-year average yield of the Hannchen barley has been equal in feeding value per acre to that of the best varieties of oats. At Newell it has yielded somewhat less than oats.

Barley varieties are separated into two main groups, two-rowed and six-rowed. The two-rowed varieties yield better than the six-rowed ones in the section under discussion. The Hannchen has yielded well at all three stations. The White Smyrna has yielded slightly more than the Hannchen at Newell and in Montana. Both Hannchen and White Smyrna are two-rowed, bearded, hulled varieties. Part of the beards of both varieties fall off when the heads are ripe. At Williston the six-rowed, hulled variety, Williston No. 170, a strain of Manchuria, has yielded about the same as Hannchen in the last four years (1913 to 1916). At Dickinson the 9-year average yield of Svanhals, a two-rowed, hulled variety, is the same as that of the Hannchen. The Hannchen is recommended for western North Dakota and the White Smyrna for western South Dakota and eastern Montana. The White Smyrna is a short-strawed variety which ripens early and thus often avoids injury from drought. In dry seasons it is sometimes difficult to harvest because of the short straw, though early-sown White Smyrna barley is usually tall enough to harvest without difficulty.

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[1] For a more complete discussion of these varieties, see Warburton, C. W., Sixty-Day and Kherson oats, U. S. Dept. Agr., Farmers' Bul. 395, 27 p., 5 fig. 1910.

At Dickinson the best variety of six-rowed barley is Gatami, an early, black variety. At Newell the Odessa is the best six-rowed variety. Neither of these has yielded as well as the two-rowed varieties. The naked (hull-less) varieties have not yielded well at any of the three stations and are not recommended. Heads of representative varieties of several groups of barley are shown in figure 8.

The highest yields of barley have been obtained from early seeding, as shown by experiments at Williston. Barley ripens more quickly than wheat or oats and may be safely sown later than the other grains if desired.

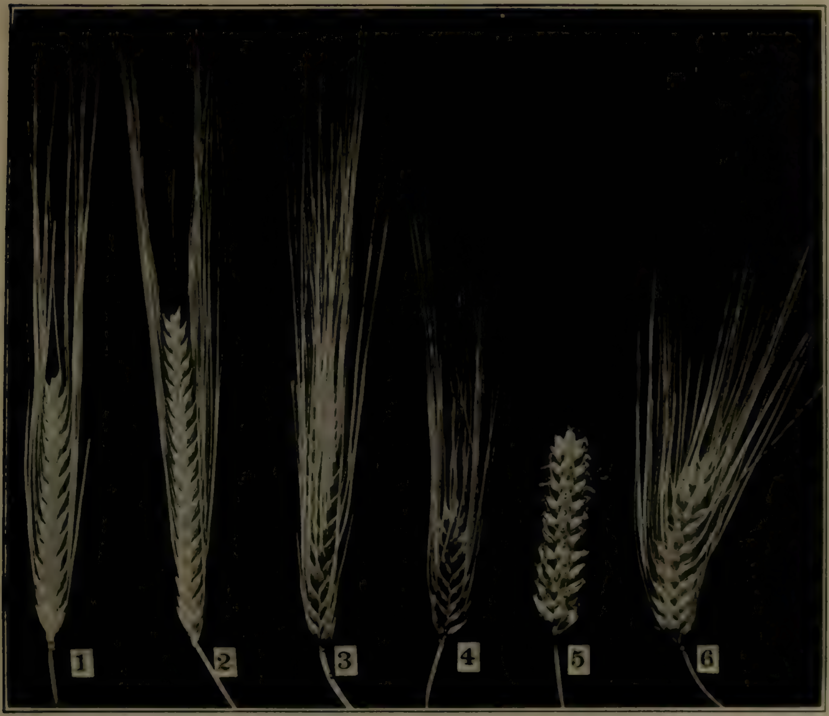

FIG. 8.—Representative heads of different types of barley; White Smyrna (1) and Hannchen (2), 2-rowed hulled varieties; Coast (3) and Mariout (4), 6-rowed hulled varieties; Nepal (5) and Himalaya (6), 6-rowed naked varieties.

Rate-of-seeding tests at Williston and Dickinson indicate that barley may be sown at rates varying from 4 to 8 pecks per acre without much difference in the average yields obtained. Results vary with different seasons. In general, the sowing of about 6 pecks per acre is recommended. In dry seasons or in dry districts thinner seeding may give better results.

FLAX.

Flax is an important crop for the new settler because of the success with which it may be grown on newly broken sod, the ready market for it, and its high price in proportion to its bulk. It also gives good returns on old land following any other grain or grass crop or after corn or potatoes. If grown continuously on the same land flax often becomes infected with disease, and weeds become troublesome. To avoid possible loss from these sources it should be included in a rotation in which it is grown on the same land only once in six or eight years.

Flax should have a firm, smooth seed bed. If sown in loose, dry soil or rough, cloddy land the plants will not come up uniformly and the stand will be uneven or thin, giving the weeds a chance to grow. On rough land some of the plants will not be cut by the binder, and this will cause considerable loss.

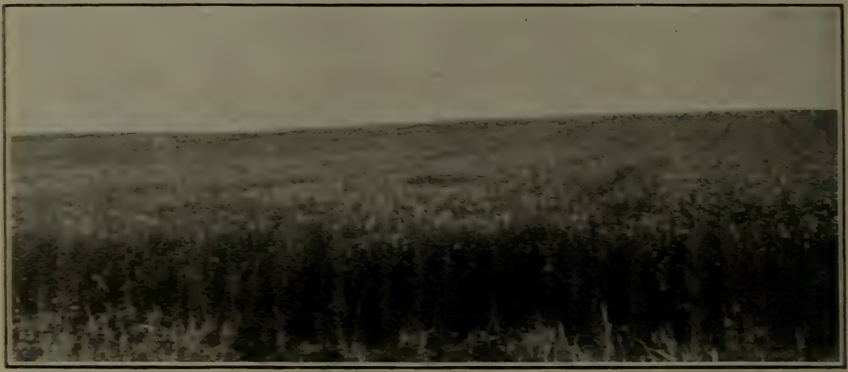

FIG. 9.—A 320-acre field of North Dakota Resistant No. 52 flax on breaking, 15 miles south of Mandan, N. Dak. The average yield of this field was 15.1 bushels per acre.

Flax is a poor weed fighter and should not be grown on land infested with weeds. The seed should be bright and plump and free from disease and weed seeds. Use the formaldehyde treatment for the prevention of disease, applying the solution as a fine spray. Stir the seed frequently to prevent it from getting too wet and sticking together.

Several varieties of the Russian seed-flax type have given good results in the region discussed in this bulletin. The best of these are North Dakota No. 155, North Dakota Resistant No. 52, and Select Russian (N. Dak. No. 1215). A field of North Dakota Resistant No. 52 flax is shown in figure 9.

Flax sown as early as May 1 usually yields better than that sown later. Flax will stand considerable freezing when it is well up, but is injured by freezing when the plants are just emerging. Late-sown flax ripens very slowly and often is injured by fall frosts. Flax sown early in June sometimes yields well, but the danger from frost in the fall is greater than in the spring.

The usual rate of seeding flax is about 2 pecks per acre. Rate-of-seeding tests have given somewhat different results for different seasons and localities. If the stand is too thin, the crop ripens unevenly and weeds have a better chance to grow. Generally from 20 to 30 pounds per acre should be sown on a well-prepared seed bed. Flax seed should be covered to a depth of 1 to 1½ inches. If covered to a greater depth the young plants may have some difficulty in reaching the surface.

MILLET.

Proso millet, known also as broom-corn millet or hog millet, is not grown very extensively in western North and South Dakota. Usually it produces less grain per acre than wheat, oats, or barley. It can be seeded in June after it is too late to sow other grains and therefore is of some value as a catch crop to be sown where other crops have failed or when it is too late to sow other grains. The best varieties of proso are Tambov, Orenburg, and Black Voronezh. The Kursk, a small, red-seeded, early variety of common or foxtail millet, has yielded nearly as well as the prosos. Millet is a rather tender crop and should not be sown until the danger of frost is over. When grown for seed, millet should be sown at the rate of about 2 pecks per acre.

RECOMMENDED VARIETIES OF SMALL GRAINS.

For western North Dakota and northeastern Montana, the following varieties are recommended:

Spring wheat: Kubanka durum, Marquis, Power Fife.
Oats: Abundance, Early Mountain, Lincoln.
Barley: Hannchen, Svanhals, Manchuria.
Rye: North Dakota No. 959.
Flax: North Dakota No. 155, North Dakota Resistant No. 52, Select Russian.

For western South Dakota and southeastern Montana, the following varieties are recommended:

Winter wheat (in the vicinity of the Black Hills): Kharkof, Turkey.
Spring wheat: Kubanka durum, Marquis.
Oats: Kherson, Sixty-Day.
Barley: White Smyrna, Hannchen, Odessa.
Rye: North Dakota No. 959, Swedish.
Flax: North Dakota No. 155, Select Russian, North Dakota Resistant No. 52.

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Oats in the Great Plains Area: Relation of Cultural Methods to Production. (Department Bulletin 218.)

Barley in the Great Plains Area: Relation of Cultural Methods to Production. (Department Bulletin 222.)

Cereal Investigations on the Belle Fourche Experiment Farm. (Department Bulletin 297.)

Tests of Corn Varieties on the Great Plains. (Department Bulletin 307.)

Barley: Growing the Crop. (Farmers' Bulletin 443.)

The Smuts of Wheat, Oats, Barley, and Corn. (Farmers' Bulletin 507.)

Growing Hard Spring Wheat. (Farmers' Bulletin 678.)

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Marquis Wheat. (Farmers' Bulletin 732.)

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Methods of Controlling or Eradicating Wild Oats in the Hard Spring Wheat Area. (Farmers' Bulletin 833.)

Growing Winter Wheat on the Great Plains. (Farmers' Bulletin 895.)

Hard Wheats Winning Their Way. (Separate 649, Yearbook, 1914.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Experiments with Wheat, Oats, and Barley in South Dakota. (Department Bulletin 39.) Price, 10 cents.

Spring Wheat in the Great Plains Area: Relation of Cultural Methods to Production. (Department Bulletin 214.) Price. 10 cents.

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Cereal Experiments at the Williston Substation. (Department Bulletin 270.) Price, 10 cents.

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The Commercial Status of Durum Wheat. (Bureau of Planty Industry Bulletin 70.) Price, 10 cents.

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Dry-Land Grains for Western North and South Dakota. (Bureau of Plant Industry Circular 59.) Price, 5 cents.

Winter Wheat in Western South Dakota. (Bureau of Plant Industry Circular 79.) Price. 5 cents.

HOME STORAGE OF VEGETABLES

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FARMERS' BULLETIN 879

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. August, 1917

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THE STORING of late vegetables is an economy for those who grow them in sufficient quantity for the needs of the family.

To care for the surplus vegetables in many cases requires nothing more than the use of existing facilities in or near the home.

Often the late vegetables from a small garden may be stored with no outlay of money.

When considerable quantities of vegetables are grown it is frequently advisable to construct permanent storage facilities in the form of a storage room in the basement of the dwelling or under an outbuilding or to build an outdoor cellar of wood or masonry.

If permanent facilities are not available late root crops can be kept in outdoor pits or banks, requiring no cash outlay except for labor.

HOME STORAGE OF VEGETABLES

CONTENTS.

Page.
Reasons for storing vegetables 3
Types of storage 4
  A storage room in the basement of the dwelling 4
  Outdoor storage cellars 6
  Storage in banks or pits 13
Storage of various vegetables 15
  Beans and peas 15
  Late beets 15
  Late cabbages 16
  Carrots 17
Storage of various vegetables—Continued.
  Late celery 18
  Onions 20
  Parsnips 20
  Potatoes, Irish 20
  Potatoes, sweet 20
  Pumpkins and squashes 21
  Salsify 22
  Late turnips 22
Storage of apples 22

REASONS FOR STORING VEGETABLES.

FOR THOSE PERSONS who are fortunate enough to control land for the growing of vegetables in sufficient quantity for the needs of the family, storage will prove an economy. Likewise, it will often prove an economy to grow late vegetables to store. Home storage is of importance at all times, but especially so if the price of suitable containers for use in canning and drying is high. Crops of suitable sorts that mature at a season when they can be preserved by storing should be kept in their natural condition instead of being canned or dried. Not only is it possible to reduce the cost of the menu materially by growing and storing vegetables for home use, but the satisfaction of having a supply of fresh vegetables near at hand, so that, regardless of markets and winter temperatures, the list may be varied, is something that can not be measured in dollars and cents.

A half-acre garden, if cared for properly, will produce far more vegetables than the average family can consume during the maturing period of the crops. Only a small portion of the garden should be devoted to those vegetables which must be used as soon as they reach maturity. Beets, late cabbage, carrots, celery, onions, parsnips, potatoes, sweet potatoes, salsify, and turnips may be stored in their natural condition, and should be grown to the extent of the family needs for storage for winter use. Beans of various kinds, including the Limas, may be stored dry. The successful storage of vegetables is not at all difficult; in fact, good storage facilities already exist in most homes, it being only necessary to make use of the cellar, the attic, a large closet, or other parts of the dwelling, depending upon the character of the product to be stored.

TYPES OF STORAGE.

A STORAGE ROOM IN THE BASEMENT OF THE DWELLING.

A cool, well-ventilated cellar under the dwelling offers good conditions for the storage of vegetables. Many cellars are not well suited for storing vegetables because of poor insulation or lack of ventilation. Cellars containing a furnace for heating the dwelling usually are too warm and too dry for the storage of root crops. It is often possible, however, to partition off a room either in one corner or at one end of the cellar where the temperature may be controlled by means of outside windows. At least one window is necessary, and two or more are desirable for admitting light and for ventilation. If the cellar is square or rectangular, a room similar to the one illustrated in figure 1 can be arranged. If, as is often the case, however, the cellar is built in the shape of an ell, the room should be made by partitioning off the offset, as shown in figure 2. In some cases it is possible to cut off one end of the cellar with one straight wall.

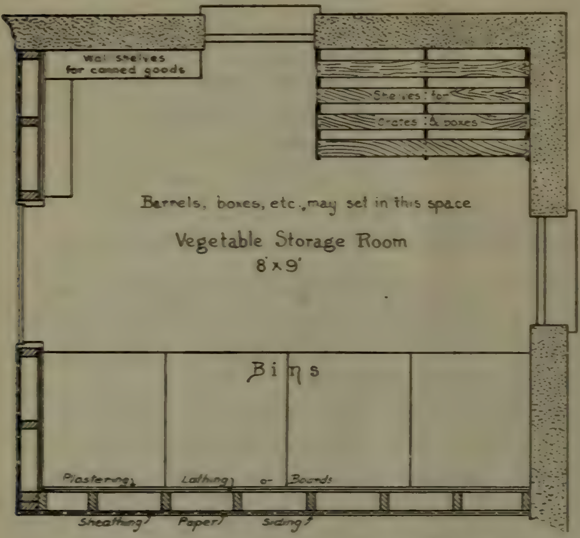


FIG. 1.—Floor plan of a storage room in a corner of a basement. The arrangement of the shelving and bins may be changed to suit conditions. While the construction of the wall may be varied, it must be tight.

CONSTRUCTION OF THE STORAGE ROOM.

The size of the storage room should be determined by the space available and the amount of material to be stored. Natural earth makes a better floor than concrete or brick, as a certain amount of moisture is desirable. The walls of the storage room should be parallel to the walls of the cellar. Lay 2 by 4 inch scantling flat on the floor and secure them with pegs driven into the floor or by nailing them to the top of short posts set in the ground. Set 2 by 4 inch studding from this sill to the ceiling, spacing them 16 inches apart from center to center. Locate the door to the storage room at the most convenient point, making it large enough to admit barrels, boxes, etc., a good size being $2\frac{1}{2}$ feet wide by $6\frac{1}{2}$ feet high. Set the studs on either side of the door 32 inches apart, which will allow for the door and the frame. Put a header over the door, allowing 1 inch for the frame and seven-eighths of an inch for the sill at the bottom. Set the studs against the walls where the cellar walls and storage-room walls meet. Care exercised in making the frame square and plumb will enable the builder to get the structure tight with a minimum of labor. A good room is made by covering the studding on the outside with tongue-and-groove material, but a better way is to sheathe the outside with plain lumber, tack building paper on this, and side with tongue-and-groove material. This construction in connection with lath and plaster or wall board on the inside makes an excellent room. The construction of such a wall is illustrated in figure 3.

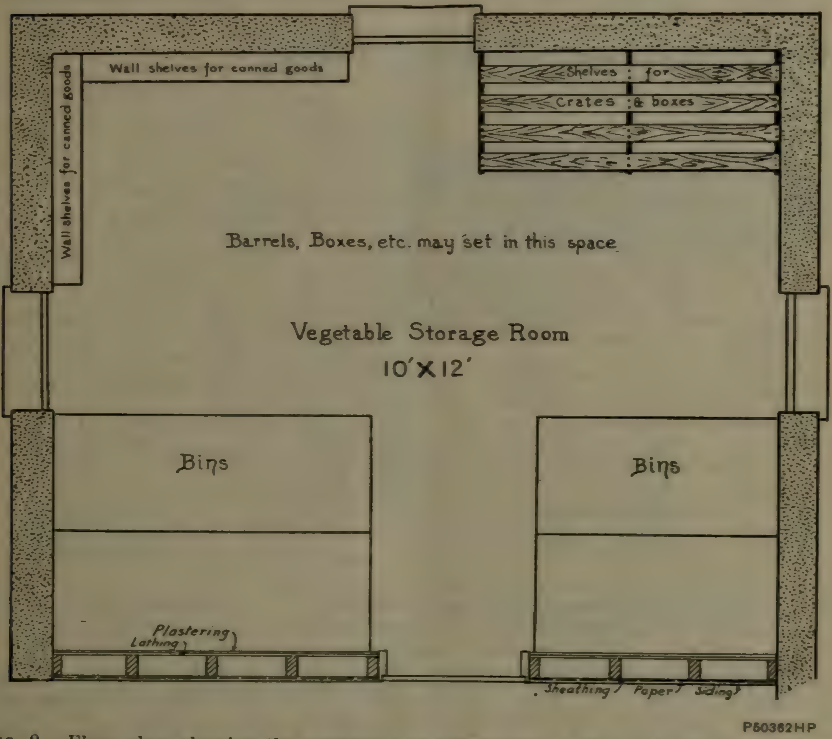

Wall shelves for canned goods
Wall shelves for canned goods
Shelves for Crates & boxes
Barrels, Boxes, etc. may set in this space
Vegetable Storage Room
10'×12'
Bins
Bins
Plastering
Lathing
Sheathing
Paper
Siding
P60362HP

FIG. 2.—Floor plan, showing the possibility of constructing a storage room by partitioning off the portion of the cellar under the wing of the house.

Ventilation may be secured by opening one or more windows. An air duct constructed of wood, metal, or terra cotta and fitted in one of the windows, as illustrated in figure 4, is desirable, as it permits the cool air to enter at the bottom of the room. Two or more joints of 6-inch stovepipe, one with a damper, and an elbow may be used. A piece of board with a hole the size of the pipe is fitted in the window in place of one of the panes of glass. Another pane of glass may be removed from the sash and a small hinged door fitted in its place, which when open allows the heated air to escape. In cold weather both the hinged door and the damper in the stovepipe must be closed. The windows in the storage room should be darkened in order to protect the vegetables from the light.

Barrels, crates, boxes, or bins may be used as containers for the various vegetables, but movable containers are preferable to built-in bins, as it is possible to remove them for cleaning. It is advisable to construct shelves or a slat floor to keep the crates, boxes, baskets, and other containers off the ground. This is highly desirable to insure a free circulation of air and to prevent the containers from harboring mice, rats, and other vermin. The shelves for canned goods along one side of the room need not be more than 6 inches wide. A suggested arrangement for the bins, shelves, etc., in the storage room is shown in figures 1 and 2.

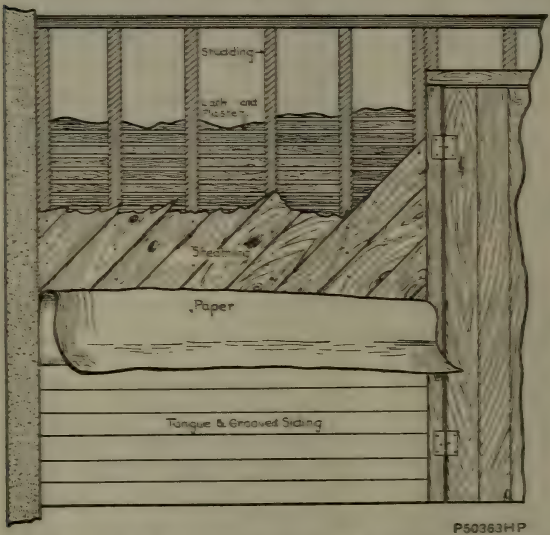


FIG. 3.—Wall of a storage room in a basement, showing the details of construction. This type of construction is good, but a satisfactory room can be made by omitting the laths and plaster. Many rooms with studding frame and tongue-and-groove siding give excellent results.

OUTDOOR STORAGE.

CELLARS.

Outdoor storage cellars or caves are excellent for the storage of many vegetables. They are particularly desirable on the farm, as they afford convenient and inexpensive storage facilities for surplus vegetable crops that otherwise might be lost. They possess all the advantages of the storage room in the basement and are superior in many respects. The outdoor storage cellar can be maintained at a uniform temperature over a long period. It is possible to keep the cellar cool and quickly to reduce the temperature of the stored product to the desired point for safe storage by opening the door during the night and closing it in the morning before the air becomes warm. All ventilators should likewise be kept tightly closed until the outside air is again cooler than that within the cellar, when they should be opened, unless the outside temperature is so low as to be dangerous. This safeguards the product and adds to the efficiency of the storage chamber. Vegetables can be more conveniently placed in such a cellar than in the storage room in the basement of a dwelling.

When the chief use of the outdoor storage cellar is for storing turnips, beets, carrots, and other root crops commonly used as stock food, it should be located near the stable, where the material will be convenient for winter feeding. When it is to be used for vegetables for the table the cellar should be accessible from the kitchen at all times. If apples or other fruits are to be stored in an outdoor storage cellar it is desirable to have a two-compartment cellar, one for vegetables and one for apples, with a ventilating apparatus in each compartment.

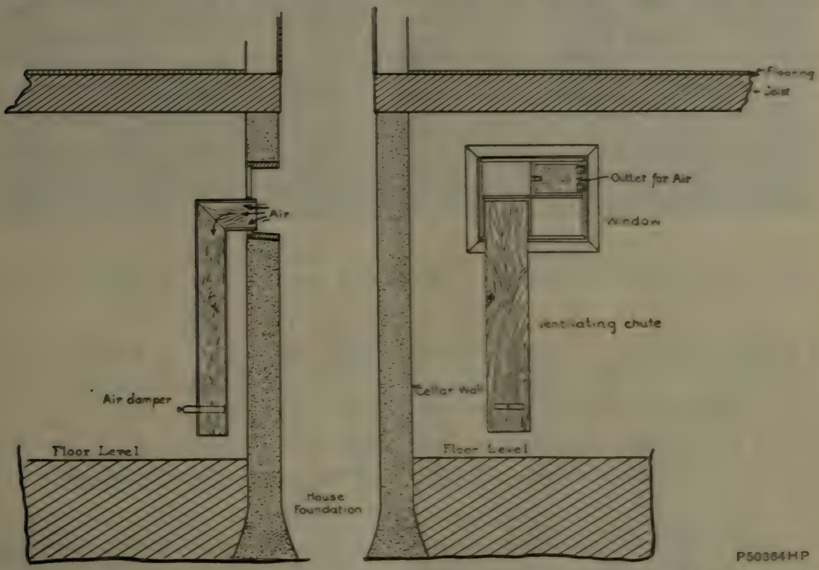


FIG. 4.—Details of construction for the ventilation of a storage room in a basement. The air duct may be made of wood, terra cotta, or metal and installed in place of a pane of glass, thus avoiding cutting through the cellar wall. A hinged door the size of another pane of glass may serve as an outlet for the warm air.

CONSTRUCTION OF THE OUTDOOR STORAGE CELLAR.

As the root cellar must be weatherproof, that is, capable of being kept free from moisture and free from frost, its type and construction vary with the geographical location. In the southern portion of the country the structure is usually entirely above ground and protected by only a few inches of sod and with straw, leaves, etc. In northern sections outdoor storage cellars are made almost entirely below ground and covered with a foot or two of earth.

STORAGE IN REGIONS OF MILD WINTERS.

An aboveground storage cellar suited to conditions in southern sections of the United States may be built on a well-drained site

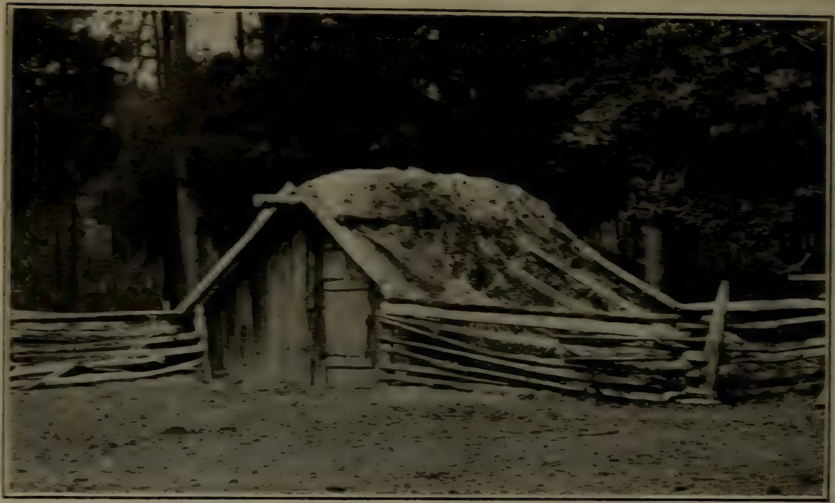


FIG. 5.—An outdoor storage cellar, typical of those used in the South for storing sweet potatoes and other root crops. It consists of a pole and plank frame covered with sod and straw.

at slight expense. A row of posts may be set 5 or 6 feet apart, extending 7 or 8 feet above the surface of the ground, with a ridgepole placed on top of them. Against each side of the ridgepole a row of planks or puncheons is placed, with their opposite ends resting in a shallow trench 4 or 5 feet from the line of posts. The ends are boarded up, a door being provided in one end of the structure, and the roof covered with sod to a depth of 5 or 6 inches. A good type of outdoor storage cellar built along these lines is shown in figure 5.

STORAGE IN REGIONS OF SEVERE FREEZES.

In sections where low temperatures prevail it is necessary to insulate the storage house so that the vegetables will not freeze. An aboveground type of storage house much used in many sections of the North has thick walls filled with insulating material, such as sawdust or shavings. The construction is of frame and the walls are usually 10 to 12 inches thick. Both the inside and the outside walls are sheathed with matched lumber so as to make them airtight. The rafters are ceiled on the under side with the same material and the space between the rafters filled with dry insulating material. The use of building paper in the roof and walls of the storage house is of great assistance in insulating it. Ventilation is provided in the same manner as in the outdoor storage cellar built of concrete described on page 12.

A type of storage cellar much used in northern sections of the country is built partly under ground. The walls are of masonry and extend to a point just above the surface of the ground. On these walls plates are set and a roof of frame construction erected. The roof structure is ceiled on the under side of the rafters and some suitable insulating material, such as dry sawdust or shavings, packed in the space between the rafters, and then the sheathing, paper, and roofing material are applied as in the case of the aboveground type of storage cellar described in the previous paragraph. This type of structure (fig. 6) is preferable in many respects to the aboveground type, as it is easier to maintain the temperature at the proper point and its insulation is a comparatively easy matter.

Protection from freezing may be secured with a simpler type of structure (figs. 7 and 8) by making it entirely under ground. In order to avoid steps down to the level of the floor, with the consequent extra labor in storing and removing the vegetables, a sidehill location is desirable.

The excavation in the hill should be of the approximate size of the cellar, using the dirt for covering the roof and for banking the sides of the structure. A frame is erected by setting two rows of posts of uniform height in the bottom of the pit near the dirt walls and a third line of posts about 5 feet higher through the center of the pit. These posts serve as supports for the planks or puncheons forming the roof of the structure, as with the aboveground type of storage cellar already described. The door is placed at one end and a ventilator put in the roof. The whole structure with the exception of the

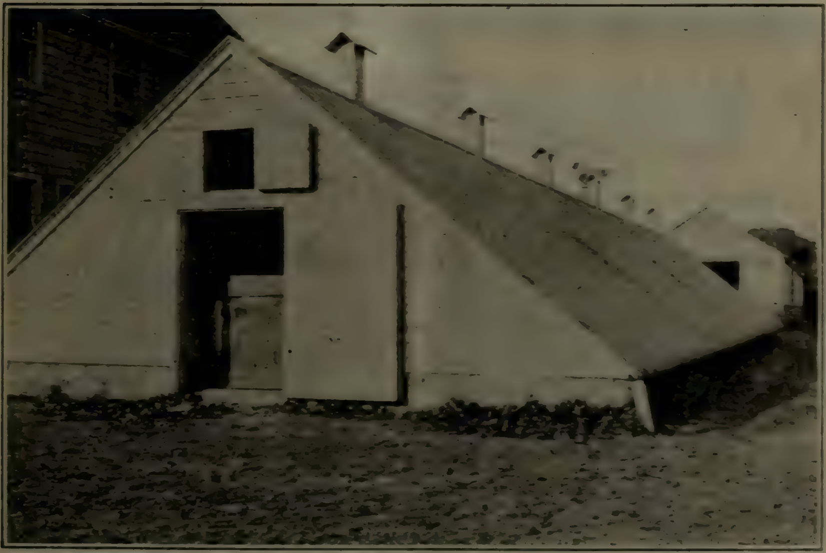


FIG. 6.—A storage cellar typical of those much used in the northern sections of the country, consisting of masonry walls and a well-insulated wooden roof.

portion occupied by the door is covered with dirt and sod. The thickness of the covering must be determined by the location; the colder the climate the thicker the covering. The dirt covering may be supplemented in winter by a layer of manure, straw, corn fodder, etc. Outdoor storage cellars usually are left with dirt floors, as a certain degree of moisture is desirable. These cellars may also be made of concrete, brick, hollow tile, stone, or other material.

OUTDOOR STORAGE CELLARS BUILT OF CONCRETE.

The type of outdoor storage cellar described above, while low in first cost, is short lived, as the conditions in the cellar are favorable to the decay of wood. The concrete storage cellar, although rather high in first cost, as compared with wood, is a permanent structure. Concrete possesses several advantages over brick, stone, or other decay-resisting materials. In the construction of a small structure suitable for the home it is possible to make the roof self-supporting and to employ unskilled labor, thus lessening the cost. It is a simple matter to waterproof concrete, a feature highly desirable in a storage cellar.

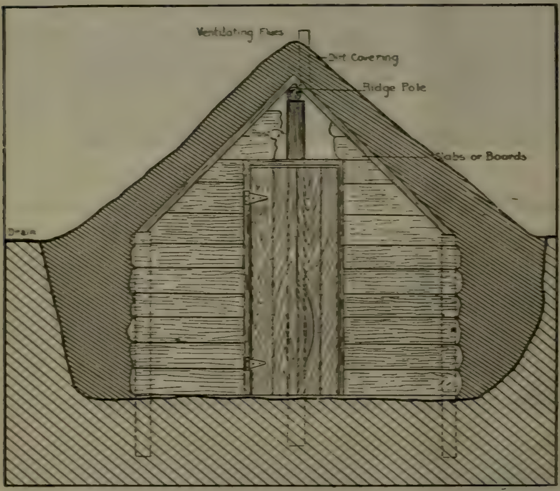


FIG. 7.—End view of an outdoor storage cellar, showing the frame of posts covered with planks or puncheons and with dirt. Additional protection may be given by placing manure, straw, or corn fodder on top of the dirt.

For detailed information in reference to the mixing and handling of concrete, the reader is referred to Farmers' Bulletin 461, entitled "The Use of Concrete on the Farm."

The site for the concrete storage cellar should be selected with the same considerations in mind as for the wood-frame cellar, namely, a well-drained, convenient location, preferably a sidehill, into which it may be built, as shown in figures 9 and 10. The excavation should be just large enough for the dirt walls to serve as the outside form for the concrete. For that portion of the wall which is above the surface of the ground a board form must be used. The inside form usually is made of boards held in place by scantling spaced about 18 inches apart. Temporary supports should be placed across the top to carry the form, so that it will be of the size and shape desired. The side

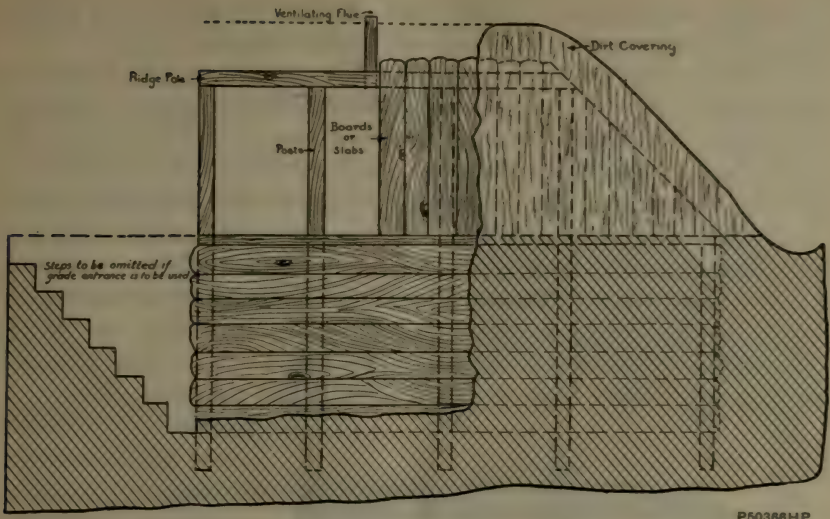


FIG. 8.—Side view of an outdoor storage cellar, showing the details of construction. If the cellar is more than 12 feet long, two ventilating flues should be used. If built on a sidehill, no steps will be needed, making it easier to store and remove the vegetables.

walls and roof should be so constructed that there will be no joints to weaken the structure. The form for the ceiling may be slightly arched by setting a temporary line of posts through the middle of the excavation. A plate placed on these posts a few inches higher than the height of the side walls will allow the form boards to be laid crosswise of the cellar, springing the ends down and securing

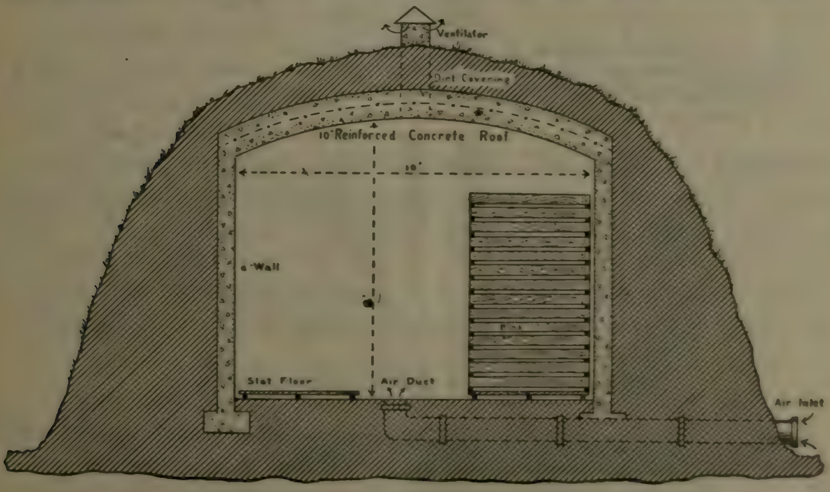


FIG. 9.—Cross section of a concrete storage cellar, showing the arrangement of ventilators, slat floors, and bins, with provision for the circulation of air under and around the slat floors and bins. This cellar is 10 feet wide and 8 feet high, inside measurement.

them to the forms for the inside of the walls. An arch a few inches high makes a strong roof and helps in ventilating the cellar.

The whole structure, with the exception of the portion occupied by the door, is covered with earth to prevent freezing, the thickness of the earth covering depending upon the geographical location. In the colder sections of the country 2 or 3 feet is not too much, and additional protection may be given by using a supplementary covering of straw, fodder, or manure. In severely cold weather both the top and bottom air ducts must be closed. It is well to cover the outside ends of the air inlets by woven wire in order to prevent small animals from entering the storage cellar.

The cellar illustrated in figures 9, 10, and 11 is 10 feet wide, 12 feet long, and 8 feet high and will contain the products of an acre garden. The walls are of 6-inch concrete reinforced by five-eighths inch iron rods. The floor is earth, as this permits good moisture conditions for the storage of vegetables. The structure is provided with a ventilating flue in the roof and an air inlet in the floor for the admission of cool air.

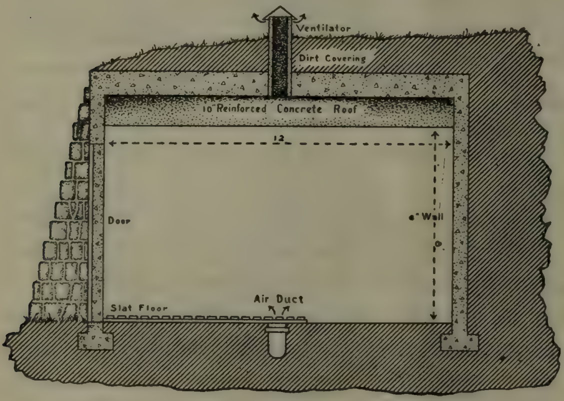


FIG. 10.—Longitudinal section of an outdoor storage cellar 12 feet long, built of concrete. The structure may be lengthened to increase the storage capacity, but if this is done additional ventilators must be provided.

The storage capacity may be increased by making the structure longer, but when this is done additional ventilators must be provided. If the width is increased, either middle piers should be used to assist in carrying the roof or the roof should be arched. A cellar 6 feet wide, 8 feet long, and 7 feet high will provide the necessary storage space for the products of a small home garden and may be built in the same manner as the one illustrated in figures 9, 10, and 11.

THE STORAGE CELLAR UNDER AN OUTBUILDING.

Sometimes it is possible to build a storage cellar as the lower story of and foundation for an outbuilding. When this is done it is desirable to have the cellar almost entirely under ground and well insulated by banking the outside walls with dirt. The ceiling of the cellar may be made frostproof by constructing a double wall to be filled with dry sawdust, shavings, or other insulating material. Concrete is a good material of which to construct the side walls of the cellar, although brick, stone, tile, etc., may be used. The entrance may be through the floor of the room above or through an outside door placed in one end of the cellar, reached by steps or a grade entrance. Ventilation may be secured by placing a shaft from the ceiling of the cellar through the room above to the roof, or by placing the ventilators in the side walls near the ceiling. The inlet ducts should be put in the floor as in other outdoor concrete cellars and their outer ends covered with wire screen.

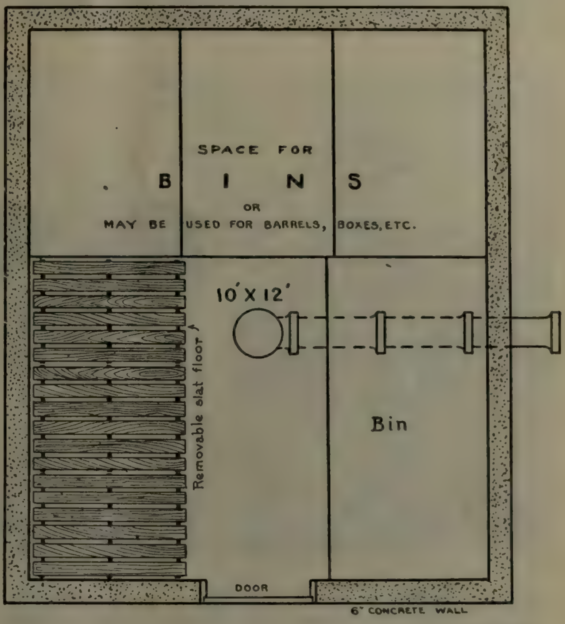


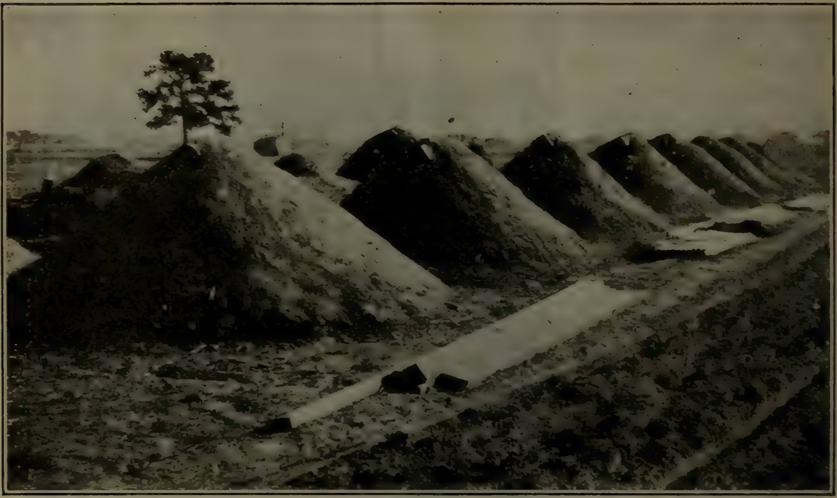
FIG. 11.—Floor plan of a simple concrete storage cellar which may be used for potatoes, beets, carrots, turnips, rutabagas, cabbage, celery, and apples. The floor is of dirt, but the barrels, crates, etc., used as containers for the vegetables, are set on a slat floor. Bins decay so quickly that barrels, boxes, etc., are usually preferable.

STORAGE IN BANKS OR PITS.

Outdoor banks or pits are used very generally for keeping vegetables. The conical pit is used commonly for such vegetables as potatoes, carrots, beets, turnips, salsify, parsnips, and heads of cabbage and is constructed as follows: A well-drained location should be chosen and the product piled on the surface of the ground; or a shallow excavation may be made of suitable size and 6 or 8 inches deep, which may be lined with straw, leaves, or similar material and the vegetables placed on the litter in a conical pile. The vegetables should then be covered with straw or similar material and finally with earth to a depth of 2 or 3 inches. As winter approaches, the dirt covering should be increased until it is several inches thick. The depth of the earth covering is determined by the severity of the winters in the particular locality. It is well to cover the pits with straw, corn fodder, or manure during severely cold weather.

The amount of ventilation necessary will depend upon the size of the pit. Small pits containing but a few bushels of vegetables will receive sufficient ventilation if the straw between the vegetables and dirt is allowed to extend through the dirt at the apex of the pile. This should be covered with a board or piece of tin held in place by a stone to protect it from rain. In larger pits ventilation may be secured by placing two or three pieces of rough boards or stakes up through the center of the pile of vegetables so that a flue is formed. This flue is capped by a trough formed of two pieces of board nailed together at right angles, as illustrated in figure 12.

Vegetables keep very well in such pits, but it is difficult to get them out in cold weather, so that when a pit is opened it is desirable to remove its entire contents at once. For this reason it is advisable to construct several small pits rather than one large one, and instead of storing each crop in a pit by itself it is better to place a small quantity of several kinds of vegetables in the same pit, so that it will be necessary to open only one bank to get a supply of all of them. In storing several crops in the same bank it is a good plan to separate them with straw, leaves, or other material. The vegetables from the small pit may be placed temporarily in the storage room in the basement, where they will be easily accessible as needed for the table.



P1311HP

FIG. 12.—Banks or pits ventilated by a flue formed of two or three pieces of board or poles capped with a trough made by nailing two pieces of board together at right angles. Banks of this kind are used for the storage of potatoes, carrots, beets, turnips, salsify, parsnips, and cabbage.

The construction of the storage bank or pit is illustrated in figures 13 and 14, figure 13 showing the cross section of a storage pit containing Irish potatoes and figure 14 one containing sweet potatoes.

STORAGE OF VARIOUS VEGETABLES.

BEANS AND PEAS.

Beans may be kept for winter use by picking the pods as soon as they are mature and spreading them in a warm, dry place, such as an attic floor, until the beans are thoroughly dry. Then shell and store in bags hung in a dry, well-ventilated place until needed. Allow navy and other bush beans to mature on the vines until a maximum number of pods are ripe; then pull the whole plant and cure it like hay. After thorough drying, thrash the beans and store as suggested above.

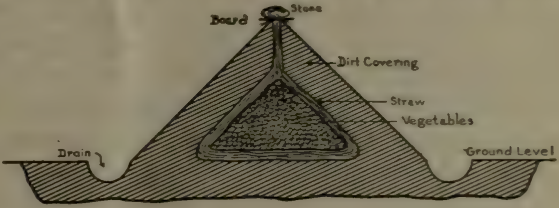


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FIG. 13.—Cross section of a storage pit containing Irish potatoes. During severely cold weather the dirt covering may be supplemented by manure, straw, etc.

Peas may be treated like bush beans and stored in the same manner.

LATE BEETS.

Storage for beets may be of any of the types described. The beets should be pulled and the tops cut off when the soil is dry. If they are to be held in the storage room in the basement or in an outdoor storage cellar, they should be placed in ventilated barrels, loose boxes, or, better still, in crates. If sufficient space is available in the cellar, it is a good plan simply to place them in small piles along

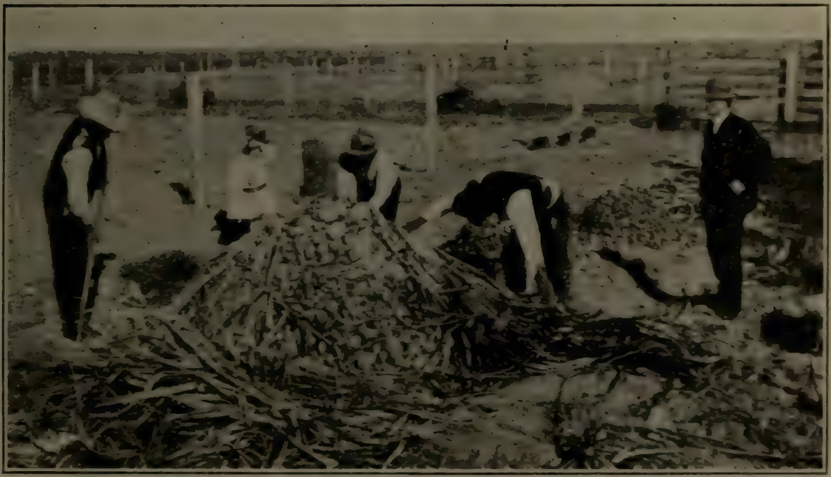

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FIG. 14.—A bank of sweet potatoes being covered with dry cane tops. Corn fodder, straw, leaves, or similar material might have been used.

the wall. Storage in large piles should be avoided, as it is liable to cause heating and decay.

For storage in banks or pits prepare the beets as for storage in the room in the basement or in the outdoor cellar. Select a well-drained location, make a shallow excavation, about 6 inches deep, line it with straw, hay, leaves, or similar material, and place the beets in a conical pile on the lining. Make the bottom of the pile about the same size as but not larger than the bottom of the excavation. Cover the beets with the same material as that used for lining the bottom of the pit, and carry it up several inches above the apex of the pile of vegetables, having it extend through the dirt covering. This serves as a ventilating flue, and it should be covered with a piece of tin or a short board as a protection from rain. The dirt covering should be 2 or 3 inches thick when the vegetables are stored, and it should be increased as severely cold weather approaches until it is a foot or more in thickness. In finishing the pit the dirt should be firmed with the back of the shovel in order to make it as nearly waterproof as possible.

The shallow trench around the base of the pit should have an outlet for carrying off the water. Supplement the dirt covering with manure, straw, corn fodder, or other protecting material. Use several small pits instead of one large one, as vegetables keep better in small pits and the entire contents may be removed when the pit is opened.

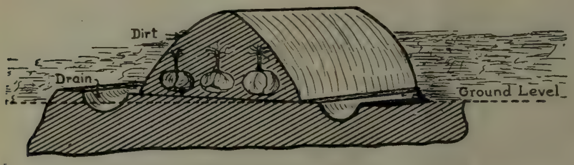

FIG. 15.—Cabbages stored in long banks. Good drainage is essential, but the dirt covering need not be as thick as for vegetables that are easily injured by frost.

LATE CABBAGES.

Heads of late cabbage may be cut and stored in conical pits in the same manner as beets. Another common and very satisfactory method is to pull the plants, roots and all, and place them in a long pit with the heads down, as illustrated in figure 15. A few heads may be removed from time to time without disturbing the remainder of the pit. As slight freezing does not injure the cabbage, the covering of the pit need not be as thick as for other vegetables.

Another good method of storing cabbage is illustrated in figure 16. The plants are pulled, roots and all, and set side by side with the roots down in a shallow trench, the length of which corresponds to the width of the bed. The bed may be any width up to 8 or 10 feet and as long as necessary to hold the number of cabbages to be stored. Cover the roots with earth. Around the bed erect a frame of rails, boards, or poles, or by driving a row of stakes into the ground so that an inclosure about 2 feet in height is formed. Bank the outside of this frame with dirt and place poles across the top, covering them with straw, hay, or corn fodder. Make provision for removing portions of the stored product from one end of the pit. This type of storage is inexpensive and gives good results. When the heads are cut, leave the roots in position, and in the spring these roots will sprout and supply the family with an abundance of greens. A large percentage of the cabbage sprouts found on the market are produced in this way.

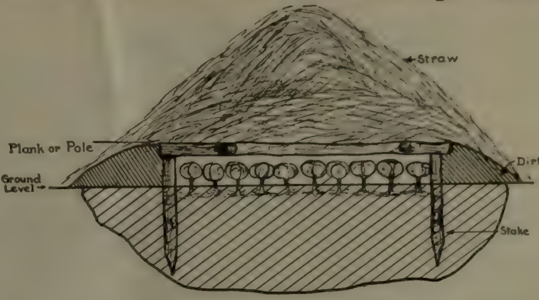

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Fig. 16.—Cross section of a cabbage storage pen made of stakes and poles and covered with straw. This is a good way to store cabbage.

Heads of cabbage may be laid in rows on shelves in an outdoor storage cellar, as shown in figure 17, but not in a storage room in the basement of a dwelling, as the odor is likely to penetrate through the house.

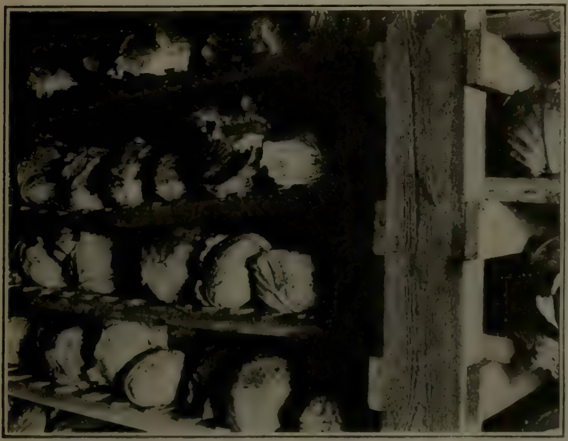

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Fig. 17.—Heads of cabbage stored on shelves in an outdoor cellar. The storage room in the basement of a dwelling should not be used, as the odor of the cabbage will penetrate through the house.

For information regarding the storage of cabbage on a large scale, see Farmers' Bulletin 433, entitled "Cabbage."

CARROTS.

Carrots may be stored in a storage room in the basement, in outdoor storage cellars, or in banks or pits, and are handled in the same way as beets. It is advisable to place a small quantity in the storage room in the basement or in the storage cellar and the remainder in banks or pits. They are not injured by slight freezing; hence need not be covered as deeply as potatoes.

LATE CELERY.

Celery may be stored for a time in the position where grown by placing enough earth around the base of the plants to hold them in good form. Allow them to remain in this condition until just before severe freezing occurs; then bank the earth up to the very tops of the plants, almost covering them, and as the weather becomes colder cover the ridge with coarse manure, straw, or corn fodder held in place by means of stakes or boards. The celery may be removed as needed, but this method is open to the objection that it is hard to get the celery out when the ground is frozen.

Another method of storing celery, illustrated in figure 18, is to excavate a pit 10 to 12 inches wide to a depth of about 24 inches and of any desired length; thoroughly loosen the soil in the bottom or shovel in loose topsoil to form a bed in which to set the roots of the celery, and pack this trench with fully grown plants, placing the roots close together with considerable soil adhering to them. Water the celery as it is placed in the trench and allow the trench to remain open long enough for the tops to become dry. Unless the soil is very dry at the time of storing or extended warm weather should follow, it will not be necessary to apply more water. Place a 12-inch board on edge along one side of the trench and bank it with the surplus earth; cover the trench with a roof of boards, straw on poles, or cornstalks from which the tops have been removed, placing

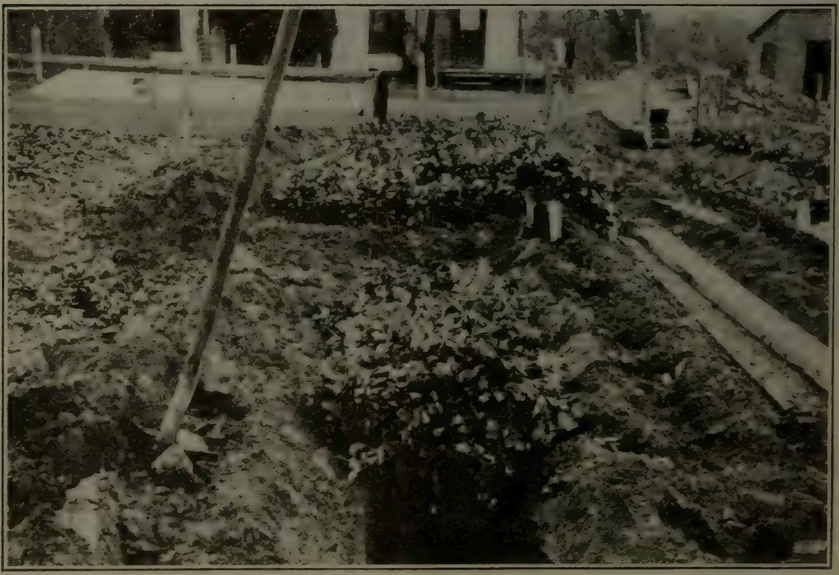
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FIG. 18.—Celery stored in trenches. A 12-inch board is placed on edge along one side of the trench and cornstalks across it, so that one end of the cornstalks rests on the board and the other on the ground.

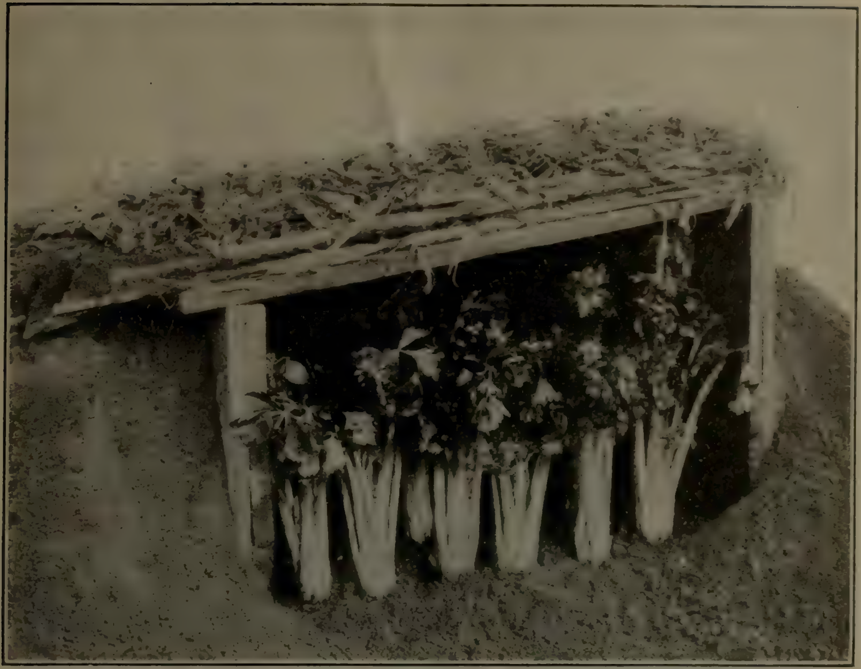

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FIG. 19.—Cross section of hotbed pit used for the storage of celery on a small scale.

the stalks across the pit with one end resting on the board and the other on the ground; spread over this a light covering of straw or other material which will pack closely, and as the weather becomes colder increase the covering to keep out the frost. Celery stored in this manner will keep until late in the winter. This method, because of its simplicity, is recommended for the farmer and small grower.

The unused pit of a permanent hotbed may be utilized as a storage place for celery by removing the surplus earth and substituting a covering of boards for the sash. Store the celery in the same manner as in the trench, and cover the bed with any material which will keep out frost. Figure 19 shows a hotbed used for this purpose.

Celery may be stored on the floor of a storage room in the basement of a dwelling or in an outdoor storage cellar. Take up the plants just before freezing occurs, with considerable earth adhering, and set them on the floor with the roots packed together as closely as possible. If moderately moist, the celery will keep well under the conditions found in most storage cellars. Celery should not be stored in the same cellar as turnips or cabbage, as it will absorb the odor of these vegetables, ruining its flavor.

For further information regarding the cultivation and storage of celery, see Farmers' Bulletin 282, entitled "Celery."

ONIONS.

To keep well, onions must be mature and thoroughly dry. Put them in ventilated barrels, baskets, crates, or loosely woven bags, as good ventilation is essential to the keeping of onions. A dry, well-ventilated place, such as an attic, furnishes a good storage space for onions, as slight freezing does not injure them, provided they are not handled while frozen.

For further information regarding the storage of onions, see Farmers' Bulletin 354, entitled "Onion Culture."

PARSNIPS.

Parsnips may be allowed to remain in the ground and dug as needed, as freezing does not injure them. However, as it is a difficult matter to dig them when the ground is frozen, it is advisable to store a small quantity in the storage room in the basement of the dwelling or in the outdoor storage cellar for use during the periods when the ground is frozen. Parsnips may be stored in the same manner as beets and carrots.

POTATOES, IRISH.

The Irish potato is the most important vegetable in the northern portions of the United States and is stored in large quantities for winter use. It may be kept in the storage room in the basement, in outdoor storage cellars, and in banks or pits. When stored in cellars, the potatoes may be put into barrels, boxes, baskets, crates, bins, or on the floor, but must be protected from the light. When stored in banks or pits they are handled in the same way as beets, carrots, etc. Potatoes must be protected from freezing, and before winter sets in the pit must be covered with manure, straw, or other material in addition to several inches of earth. It is a good plan to place the major portion of the crop in banks or pits and a small quantity in the storage room in the basement or in the outdoor storage cellar for immediate use. A good type of storage cellar especially designed for potatoes is shown in figure 20.

For more detailed information on the storage of potatoes, read Farmers' Bulletin 847, entitled "Potato Storage and Storage Houses."

POTATOES, SWEET.

Sweet potatoes should be mature when dug and should be left exposed for a few hours to dry off the surface moisture before being placed in storage. They should be handled carefully at all times, as they are bruised easily. This crop may be kept in pits or banks or in outdoor storage cellars of the type shown in figure 5, but a warm, dry place is preferable. When stored in pits or banks sweet potatoes are handled in much the same way as beets or other root crops. When kept in a specially constructed storage house, either in bulk or in crates, the potatoes should be cured for about 10 days or two weeks at a temperature of 75° to 80° F. After the curing period the temperature should be reduced gradually to about 55° F. and maintained at that point or as near it as practicable for the remainder of the storage period. When well matured before digging, carefully handled, well cured, and held at a uniform temperature of about 55° F., sweet potatoes may be kept throughout the winter and spring. When only a few bushels of sweet potatoes are to be stored, they may be placed in the basement near the furnace, on a shelf near the kitchen stove, near the chimney on the second floor, or even in the attic.

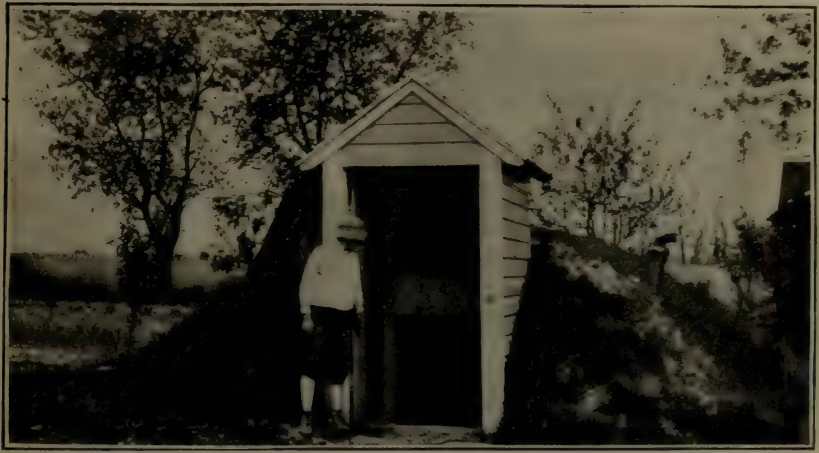

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FIG. 20.—A small storage cellar, suitable for holding the products of a home vegetable garden. It is of concrete, is built partly under ground to make it frost proof, and has a small frame entrance.

For more detailed information on the storage of sweet potatoes, read Farmers' Bulletin 548, entitled "Storing and Marketing Sweet Potatoes."

PUMPKINS AND SQUASHES.

Pumpkins and squashes may be kept for winter use in the storage room in the basement or in dry, well-ventilated cellars, but a dry, aboveground, frostproof place is best. Put them in rows on shelves so that they are not in contact with each other. If the temperature is maintained at about 40° F., late-maturing varieties of these vegetables will keep until late in the winter.

SALSIFY.

Salsify may be stored in the same way as beets, carrots, and parsnips.

LATE TURNIPS.

Turnips will withstand hard frost, but alternate freezing and thawing injures them. Gather, top, and store the roots in banks or pits, or in an outdoor storage cellar. Do not place them in the storage room in the basement of the dwelling, as they give off odors that penetrate throughout the house.

STORAGE OF APPLES.

Apples may be kept in the storage room in the basement of the dwelling, in outdoor storage cellars, and in banks or pits. Conditions suitable for the keeping of potatoes answer fairly well for apples. Under some conditions it will be an advantage to store part of the crop in the cellar and the late-keeping varieties suitable for spring use in outdoor banks or pits.

For further discussion of the storage of apples, see Farmers' Bulletin 852, entitled "Management of Common Storage Houses for Apples in the Pacific Northwest."

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FUMIGATION OF ORNAMENTAL GREENHOUSE PLANTS WITH HYDROCYANIC-ACID GAS

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BY THE CAREFUL use of hydrocyanic-acid gas in accordance with the directions given in this bulletin practically all insects infesting the foliage of ornamental plants in greenhouses may be controlled, and more cheaply and effectively than by any other means.

In fumigating a house containing a large variety of plants, using the correct dosage and under proper conditions, the tender growth of some plants may be injured. This injury is not permanent, however, and such plants will show new vigorous growth in a short time. Moreover, the growth of many plants is stimulated by hydrocyanic-acid gas.

Chemicals required in fumigating with hydrocyanic-acid gas are sodium cyanid containing not less than 51 per cent cyanogen (or potassium cyanid containing not less than 38.4 per cent cyanogen), sulphuric acid 93 per cent pure, and water. Cyanid for fumigation purposes should be practically free from chlorin.

Fumigation should not be undertaken in daylight or when the temperature in the greenhouse is below 52° F. or above 70° F.

Cyanid is one of the most poisonous substances known. Care should be taken to observe the precautions stated on pages 11 and 12.

FUMIGATION OF ORNAMENTAL GREENHOUSE PLANTS WITH HYDROCYANIC-ACID GAS.

CONTENTS.

	Page.		Page.
Equipment necessary for fumigation	3	Exposures	9
Preparation of greenhouse for fumigation	4	Ventilation after fumigation	9
Method of computing the cubical contents of even and three-quarter span greenhouses	5	Effects of weather and other conditions on fumigation	9
Time for fumigation	5	Advisability of a fumigation box	10
Chemicals required for fumigation	6	How greenhouses become infested with insects	10
Determining the amount of cyanid to be used	6	Cost of hydrocyanic-acid gas fumigation	11
Chemical formula to be employed	8	Precautions	11
Mixing the chemicals	8	Guide to greenhouse fumigation	12
Number of generators to be employed	9		

HYDROCYANIC-ACID GAS, if intelligently employed, is one of the cheapest and most efficient methods of controlling thrips, aphids, white flies, and various scale insects on plants grown under glass. This method of control, however, has not been adopted generally because of the deadly poisonous nature of the gas if inhaled, its disastrous effect on tender plants if improperly used, and the prevailing impression that fumigation is a cumbersome procedure requiring considerable skill on the part of the operator. It is true that much damage to the plants and injury to the operator may result from the *careless* use of hydrocyanic-acid gas, but it is an established fact also that this fumigant in competent hands is a safe, practical, and economical means of controlling virtually all insect pests found in greenhouses.

EQUIPMENT NECESSARY FOR FUMIGATION.

GENERATORS.

One-half-gallon or one-gallon glazed earthenware jars serve as satisfactory generators, although it is preferable that the bottoms of the jars be rounded inside, so that the cyanid will be covered with the acid and water, even with small doses, thus insuring the maximum generation of the gas.

CAUTION.—*Hydrocyanic-acid gas is colorless and is one of the most deadly poisonous gases known. It has an odor much like that of peach pits. In case of accidental inhalation of the gas, the person affected should be kept in the open air and required to walk to increase respiration.*

Crocks with straight sides are frequently sold with glazed earthenware tops. These tops or covers increase the cost of the generators and, furthermore, are useless for fumigation purposes. Therefore, when generators are ordered it should be indicated that tops are not desired.

MISCELLANEOUS REQUIREMENTS.

Correct scales or balances, reading in tenths of an ounce, are convenient for accurate work. An 8-ounce graduate is desirable for measuring the acid and water. To avoid splashing of the acid it should not be poured from a carboy or bottle into the graduate but should be transferred to a porcelain pitcher, from which it may be poured with safety. It is well to have on hand a supply of small bags in which to place the cyanid.

PREPARATION OF GREENHOUSE FOR FUMIGATION.

As a preliminary to fumigating the greenhouse it is essential that the exposed glass surface be examined carefully and all broken glass replaced. All cracks should be closed thoroughly. The ventilators—both side and top, where possible—should be so arranged that they can be opened from the outside of the greenhouse upon the completion of the exposure. This can be accomplished by disconnecting the "machine," or gear, of the top ventilators and attaching to the central ventilator shaft (see figs. 1 and 4) an arm (*a* or *b*) which can be controlled by a cord or wire which extends through the side of the greenhouse. The gears on the side ventilators may be disconnected so that the sash may be opened from the outside. If only one ventilator can be opened, it is preferable that it be the one on the roof of the greenhouse.

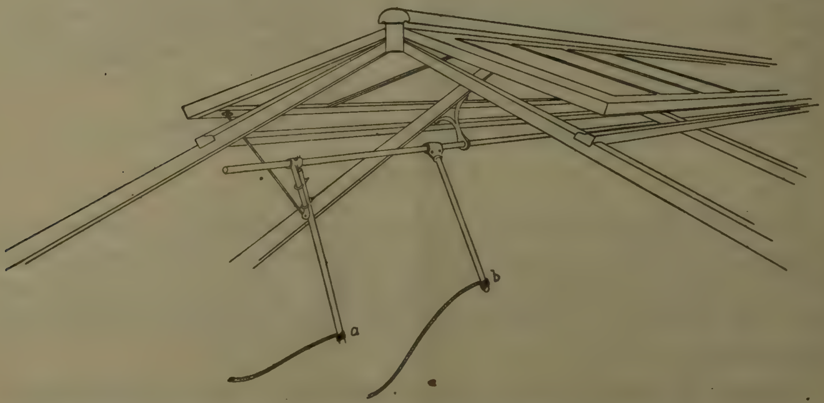

FIG. 1.—Methods of attaching rod and cord (*a*, *b*) to ventilator shaft of greenhouse so that the ventilators can be opened from the outside after fumigation.

METHOD OF COMPUTING THE CUBICAL CONTENTS OF EVEN AND THREE-QUARTER SPAN GREENHOUSES.

It is essential in every instance that the cubical contents of the greenhouse to be fumigated be determined accurately, and the following is a simple method of arriving at these figures: To facilitate matters a diagram indicating the necessary dimensions of the greenhouse should be made. (See figs. 2 and 3.)

To secure the cubical contents of the even-span greenhouse (fig. 2), compute the number of square feet in the rectangle *a* and in the right-angle triangles *b* and *c* and multiply the sum of the three by the length of the greenhouse. For example, $a=5\times20=100$ square feet; $b=5\times10\div2=25$ square feet;[1] and $c=5\times10\div2=25$ square feet. $a+b+c=150$ square feet. 150 square feet × 100 feet (length of house) = 15,000 cubic feet, cubical contents of the greenhouse.

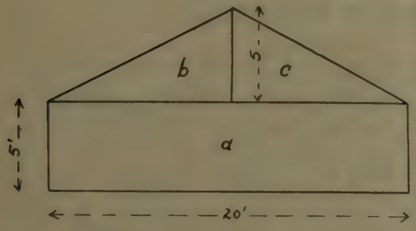

FIG. 2.—Diagram showing method of computing cubical contents of even-span greenhouse.

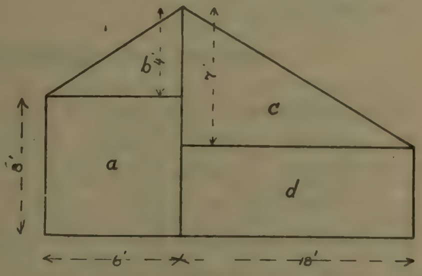

FIG. 3.—Diagram showing method of computing cubical contents of three-quarter-span greenhouse.

To secure the cubical contents of the three-quarter-span greenhouse (fig. 3), multiply the sum of the rectangles *a* and *d* and right-angle triangles *b* and *c* by the length. For example $a=6\times8=48$ square feet; $d=18\times5=90$ square feet; $b=6\times4\div2=12$ square feet; and $c=18\times7\div2=63$ square feet. $a+d+b+c=213$ square feet. 213 square feet × 100 feet (length of house) = 21,300 cubic feet, cubical contents of greenhouse.

In estimating the cubical contents of a greenhouse it is not necessary to make allowances for the space occupied by the benches, pots, etc.

TIME FOR FUMIGATION.

Fumigation should be conducted not earlier than one hour after sunset and should not be attempted when the wind is high. It is undesirable to fumigate during extremely cold nights, when the thermometer is registering near zero, owing to the necessity of ventilating the greenhouse upon the completion of an exposure. It is inadvisable to fumigate on hot, humid nights, when the temperature in the greenhouse can not be lowered readily to the desired limit. The best temperature for fumigation is between 55° and 68° F.

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[1] To calculate the area of a right-angle triangle, multiply the base by the perpendicular and divide the product by two.

The interval between fumigations naturally should be governed by the reappearance of the insect under control. With small dosages, which are imperative when fumigating a greenhouse containing an assortment of plants, it is possible to kill only the larvæ of scale insects, the adults and first larva stages of the greenhouse white fly, the adults of the Florida fern caterpillar, greenhouse leaf-tyer, and loopers, and a certain percentage of aphids. The eggs and pupæ of most greenhouse insects offer considerable resistance to hydrocyanic-acid gas, and, furthermore, the overlapping of broods necessitates several fumigations at short intervals. It has been proved repeatedly that three or four fumigations at short intervals will give practical control.

CHEMICALS REQUIRED FOR FUMIGATION.

The chemicals required in fumigating with hydrocyanic-acid gas are sodium cyanid ($NaCN$) or potassium cyanid (KCN), sulphuric acid (H_2SO_4), and water (H_2O). Potassium cyanid has been superseded recently by sodium cyanid in the generation of this gas, and the former is rarely used nowadays in fumigation. Sodium cyanid for fumigation purposes should be practically free from chlorin and should contain not less than 51 per cent of cyanogen. It may be purchased either in lumps or in the shape of an egg, each "egg" weighing approximately 1 ounce. The latter is easily handled and the necessity of weighing each charge is obviated, provided, of course, the dosage is in ounces. For example, if the greenhouse requires 10 ounces of cyanid, 10 "eggs" are used. In small dosages, however, where the cyanid is measured in grams, it is necessary to use small lumps or break up the "eggs."

Cyanid is one of the most poisonous substances known and should be stored in air-tight cans, plainly labeled, and kept out of reach of those unacquainted with its poisonous nature.

Commercial sulphuric acid (about 1.84 sp. gr. or 66° Baumé) that is approximately 93 per cent pure is commonly used and gives very satisfactory results. The acid should be kept in a glass receptacle, properly labeled, and tightly corked with a glass stopper.

DETERMINING THE AMOUNT OF CYANID TO BE USED.

Satisfactory results are obtained only where it is possible to overcome the resisting power of the insects without overcoming the resisting power of the plant. Under favorable conditions greenhouses that do not contain roses, rose geraniums, asparagus ferns, lemon verbenas, snapdragons, wandering Jew, or sweet peas can be fumigated with safety with an initial dosage of one-half ounce of sodium cyanid (NaCN) per 1,000 cubic feet. *In case there is any doubt as to the amount of gas a plant will stand without injury, it is preferable that the initial dosage be not over one-fourth ounce of sodium cyanid per 1,000 cubic feet* and increased with subsequent fumigations until the fatal point for the pest to be controlled is reached, it being borne in mind that in some instances it is not possible to effect an absolute control of all stages of some insects with one fumigation without injury to foliage or growing parts of certain plants. For example, the greenhouse white fly can be eradicated with three successive fumigations at intervals of seven to nine days, using one-half ounce of sodium cyanid (NaCN) per 1,000 cubic feet, in houses containing such susceptible plants as coleus, ageratum, heliotrope, fuchsia, etc., with no injury to the foliage. Moreover, such resistant pests as scale insects can be eliminated entirely by killing the immature stages with a small dosage repeated at frequent intervals.

To determine the total amount of cyanid to be used, ascertain from Table II on page 13 the plants in your greenhouse which are most easily injured by the gas fumes and note the amount of cyanid which was used per 1,000 cubic feet with little or no injury to the plants. Then multiply the number of thousand cubic feet contained in the greenhouse by the amount of cyanid to be used per 1,000 cubic feet. For example, if one-half ounce of cyanid is to be used per 1,000 cubic feet, and the greenhouse contains 15,000 cubic feet, the total amount of cyanid necessary would be 7½ ounces.

In case there is any doubt as to the amount of gas the plant can stand without injury, the initial dosage, as previously stated, should not exceed one-fourth ounce per 1,000 cubic feet.

Table I gives the amount of sodium cyanid per 1,000 cubic feet needed to destroy the insect pests most commonly found in greenhouses. *Before fumigation is begun, however, Table II should be consulted for information as to the maximum dosage the particular plants can stand without injury. If this dosage is less than that indicated in Table I, complete control, of course, should not be attempted with one fumigation*

TABLE I.—*Amounts of cyanid and number of fumigations sufficient to destroy various greenhouse pests.*

Insects.	Ounces per 1,000 cubic feet.	Number of fumigations required.	Interval between fumigations.
			Days.
Aphids[1]	½	1	
Azalea lacewing	½	1	
Thrips	½	2	10.
Greenhouse white fly	½	3	7 to 9.
Long scale	¾	1	
Greenhouse Orthezia[2]	¾	2	21 to 28.
Palm mealybug[2]	2½	1	
Palm aphis	2½	1	
Long-tailed mealybug[2]	2½	2	Do.
Florida red scale	2½	2	Do.
Thread scale	2½	2	Do.
Aspidistra scale	2½	2	Do.
Soft brown scale	2½	2	Do.
Hemispherical scale	2½	2	Do.
Tessellated scale	2½	2	Do.
Florida fern caterpillar	5	1	
Citrus mealybug[2]	5	2	Do.

[1] For the most part aphids can be controlled with one-half ounce of sodium cyanid per 1,000 cubic feet, although there are a few species which are quite resistant to this gas and not so readily killed.

[2] The greenhouse Orthezia and mealybugs around the roots of plants are very difficult to kill, and this dosage is recommended only for those occurring above the soil.

CHEMICAL FORMULA TO BE EMPLOYED.

The chemicals[1] should be mixed in the following proportions: For each ounce of sodium cyanid use 1½ fluid ounces of sulphuric acid and 2 fluid ounces of water.

MIXING THE CHEMICALS.

After the generators have been distributed throughout the greenhouse, and before the chemicals have been mixed, the cyanid should be weighed accurately and the proper amount for each generator placed in a paper bag near the generator. The chemicals should be mixed invariably in the following manner: First, measure and place in each generator the amount of water required; second, measure and place in each generator the amount of sulphuric acid required; third, drop the cyanid into the diluted warm acid in each generator, immediately leave the greenhouse, and post a danger sign on the closed door. The cyanid should be dropped gently from the bag, not thrown, into the generators, and the operator should begin at the generator farthest from the door and work toward the door. In case there are two rows of generators the cyanid should be dropped simultaneously by two operators. As little time as possible should elapse between the addition of the acid and the addition of the cyanid, as the heat which is liberated by the mixing of the acid and water assists in the generation of the gas.

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[1] If potassium cyanid is used in place of sodium cyanid, the formula should be as follows: For each ounce of 98 to 99 per cent potassium cyanid containing 38.4 per cent cyanogen use 1 ounce of sulphuric acid and 3 ounces of water. The yield from 1 ounce of high-grade sodium cyanid is equivalent to the yield from 1⅓ ounces of high-grade potassium cyanid.

The residue left in the generators after fumigation should be buried or poured into a sink and the generator washed before being stored for future operations.

NUMBER OF GENERATORS TO BE EMPLOYED.

The number of generators to be employed will depend largely upon the size of the greenhouse, and they should be so arranged that the gas will be distributed uniformly throughout the inclosure. To secure this advantage a number of generators should be used rather than one large generator. Generators should be spaced from 20 to 25 feet apart (see fig. 4), and in case of a light wind a few extra generators should be placed on the windward side of the greenhouse. An ounce to each jar is as small a dose as is practicable, unless the generators are well rounded inside at the base or well tilted.

EXPOSURES.

Short exposures with a greater strength of gas are more satisfactory than a weaker strength of gas overnight. In fact, better results will be gained if the exposures do not exceed one to two hours. An exposure of one hour is satisfactory in most instances. Short exposures also have the additional advantage of permitting the greenhouse to become thoroughly aired previous to the rising of the sun.

VENTILATION AFTER FUMIGATION.

If there is a light wind, a ventilation of 10 to 15 minutes, using side and top ventilation, will be sufficient and will not lower the greenhouse temperature to a dangerous point unless it is close to zero weather outside. If it is a still evening and the outside temperature is not below 32° F., a 20 to 30 minute ventilation will be satisfactory. In case it is necessary to enter the greenhouse shortly after ventilation to determine the temperature, the person entering should not remain any longer than is necessary.

EFFECTS OF WEATHER AND OTHER CONDITIONS ON FUMIGATION.

TEMPERATURE.

It is not advisable to fumigate if the temperature in the greenhouse exceeds 70° F. or if the temperature is less than 52° F.

LIGHT.

Light unquestionably affects fumigation. It has been known for a long time that it is very unsafe to fumigate when the sun is high. Furthermore, some injury may result to plants which have been subjected to fumes if, on the following day, the sun is very bright.

MOISTURE.

Hydrocyanic-acid gas is readily soluble in water, and as a result the presence of excessive moisture in greenhouses decreases the effectiveness of the gas and consequently lessens the possibility of injury to the plants by burning. It is obvious, therefore, that in order to increase the effectiveness of the fumigation the plants should be syringed not less than four or five hours prior to the liberation of the gas, to avoid undue absorption of the gas by the water on the benches and walks.

HUMIDITY.

A relatively high humidity (98 to 100), with temperature varying from 70° to 75° F., greatly increases the amount of injury to the foliage of the plants, whereas plants in the presence of the same high humidity (98 to 100), with a temperature of 60° to 65° F., will exhibit little if any injury.

ADVISABILITY OF A FUMIGATION BOX.

A fumigation box is desirable for two reasons, namely, for testing the amount of gas plants can stand without injury, and for ridding a limited number of potted plants of insects, and thus avoiding costly and laborious hand scrubbing of such plants. The size of the box will depend on the use to which it is to be put. A box with a capacity of 200 cubic feet can be used advantageously for nursery stock, palms, etc.

Plants to be fumigated in a box in the daytime should remain in the box with the door closed at least one hour before the gas is generated and should be shaded from the bright sunlight for at least two hours after the completion of the exposure.

HOW GREENHOUSES BECOME INFESTED WITH INSECTS.

Doubtless many greenhouses become infested with insects through the agency of plants commonly referred to as "boarders." The practice of turning over home-grown plants to a florist to care for during the absence of the owner on a vacation is prevalent over the entire country, and often results in establishing pests not hitherto known to occur on the florist's premises. If the trade requires such a practice, plants of this character should be cleaned thoroughly of insect pests before being placed with the regular stock of the greenhouse.

Insect infestations in greenhouses have been traced to the following sources: Infested plants brought in from coldframes or propagating beds which have not received proper attention; cuttings, plants, and buds received from other establishments; and imported foreign or domestic stock. Adults of the greenhouse white fly, grasshoppers, beetles, aphids, etc., may enter through open ventilators from other greenhouses or gardens; cutworms, wireworms, white grubs, etc., may be brought into the greenhouse with the soil; and roaches, ants, sowbugs, millipedes, etc., are sometimes brought in with packages, or they may crawl into the greenhouse through small openings.

COST OF HYDROCYANIC-ACID GAS FUMIGATION.

The economy in the use of hydrocyanic-acid gas as a means of controlling aphids, white flies, thrips, and the common greenhouse scale insects is apparent from the following figures, which are based on current manufacturers' prices:

For the most part, aphids can be controlled with a single fumigation at the rate of one-half ounce per 1,000 cubic feet at a cost of approximately 1 cent per 1,000 cubic feet. Tobacco fumigation with standard tobacco paper costs from 1½ to 3 cents per 1,000 cubic feet, and to secure a satisfactory control the operation must be repeated several times. Standard nicotine soap solution costs from 1 to 3 cents per gallon, and 4 gallons are required to cover plants which would occupy 1,000 cubic feet of space.

The greenhouse white fly can be controlled with three successive fumigations at the rate of one-half ounce of sodium cyanid per 1,000 cubic feet, with a total cost of 3 cents per 1,000 cubic feet for a complete control. Standard insecticides cost about 6 cents per 1,000 cubic feet for a single application, and fully four applications are required for a satisfactory control.

Thrips can be controlled on such plants as azaleas, lilies, and ferns with a single fumigation at the rate of one-half ounce of sodium cyanid per 1,000 cubic feet at a cost of 1 cent per 1,000 cubic feet. A single application of nicotine soap solution costs fully five times as much as the gas treatment and still gives only a partial control.

The common scale insects of greenhouses (excepting mealybugs) can be controlled by fumigating the infested plants at the rate of three-fourths ounce of sodium cyanid per 1,000 cubic feet at a cost of 1½ cents per 1,000 cubic feet. The standard proprietary insecticides commonly recommended for scale insects cost approximately 4 cents per gallon, with an average cost of 16 cents per 1,000 cubic feet for each treatment. A 5 per cent homemade kerosene emulsion costs approximately one-half cent more per 1,000 cubic feet than does the gassing method, and gives very indifferent results.

The foregoing figures do not take into consideration the cost of labor. The time required for fumigation, however, will not exceed the time required for the mixing and application of the sprays.

PRECAUTIONS.

Do not *guess* the amount of chemicals to be employed or the cubic contents of the house.

Do not fumigate plants in a greenhouse in daylight. (For box fumigation in daytime, see page 10.)

Do not fumigate when the temperature in the greenhouse is below 52° or above 70° F.

Do not leave the chemicals within reach of those unacquainted with their poisonous nature. Always have them properly labeled.

Do not handle the chemicals any more than is absolutely necessary. It is well to have a pair of old gloves for this, and to use them for no other purpose. Always wash the hands thoroughly after handling the chemicals whether gloves have been used or not.

Do not allow the acid to splash or drop on the clothing or skin.

Do not stay in the greenhouse any longer than is necessary to place the cyanid in the jars, and *never* enter a greenhouse charged with the gas until it has been thoroughly aired.

Do not fail to post danger signs at all entrances before setting off the charge, and to see that the greenhouse is closed tightly.

Do not attempt to fumigate without adjusting the ventilators so that they can be operated from the outside.

Do not attempt to fumigate a large greenhouse alone.

Do not fumigate a greenhouse adjoining a dwelling without notifying the occupants before fumigation.

Do not pour the water on the acid; pour the acid on the water.

Do not become negligent in any of the precautions; to do so may cause serious results.

GUIDE TO GREENHOUSE FUMIGATION.

Table II is offered as a guide to those desiring to employ hydrocyanic-acid gas for controlling greenhouse pests. As indicated in this table, certain insects and plants are more resistant to hydrocyanic-acid gas than are others, and this fact should be borne in mind when a greenhouse containing a miscellaneous collection of plants is to be fumigated.

TABLE II.—*Results of fumigation with hydrocyanic-acid gas in greenhouses and boxes.*

[Plants with an * were fumigated in a box.]

Name of plant.	Rate in ounces per 1,000 cubic feet.		Exposure in hours.	Greenhouse temperature.	Infestation.	Results of treatment.	
	Sodium cyanid.	Potassium cyanid.				On plants.	On insects.
				°*F.*			
Abutilon sp	½	......	1	58	Greenhouse white fly.	No burning	All stages except eggs and late pupæ killed.
Do	¾	......	1	68	do	do	Do.
Acalypha sp	¾	......	1	60		do	
Achyranthes sp	¾	......	1	60		do	
Ageratum sp	½	......	1	58	Greenhouse white fly.	do	Do.
Do	5	......	1	52		Tender tips burned.	
Air plant	¾	......	1	68	Aphids	No burning	100 per cent killed.
Allamanda hendersoni	½	......	1	60		do	
Alpinia sanderae	½	......	1	62		do	
Alternanthera sp	½	......	1	60		do	
*Do	......	10	1	73		do	
Althea sp	½	......	1	60	Aphids	do	Do.
Amaranthus sp	¾	......	1	55		do	
Amaryllis sp	¾	......	1	68		do	
Anthericum comosum	½	......	1	60	Long scale	do	80 per cent killed
Do	¾	......	1	60	do	do	100 per cent killed.
Anthurium sp	½	......	1	60		do	
Ardissia sp	½	......	1	62		do	
Araucaria excelsa	½	......	1	66		do	
Aristolochia sipho	......	5	¾	66		do	
Artemisia sp	......	1½	1	73		Slight burning	
Artillery plant	½	......	1	70		No burning	
Asparagus plumosus	½	......	1	66		Tips burned	
Asparagus sprengeri	½	......	1	60		Tender tips burned.	
Aspidistra lurida	2½	......	1	62	Florida red scale	No burning	Do.
Aster	½	......	1	62		do	
Aucuba japonica	¾	......	1	68		do	
Azalea sp	5	......	1	50	Greenhouse thrips.	do	Do.
Do	½	......	1	60	do	do	Do.
Do	½	......	1	60	Azalea lacewing	do	Do.
Do	¾	......	1	60	Azalea Eriococcus.	do	50 per cent killed.
Do	......	7½	1	......		Slight burning	
Begonia sp	½	......	1	60	Greenhouse Orthezia.	No burning	70 per cent killed.
Do	5	......	1	52		do	
Berberis rehderiana	½	......	1	62		do	
Bougainvillea	¾	......	1	56		do	
Do	5	......	1	52		Foliage burned	
Buxus sp	......	7½	1	......		No burning	
Calendula	½	......	1	60		do	
Caladium	5	......	1	52		do	
Camellia japonica	5	......	1	52	Citrus mealybug.	do	100 per cent killed.
*Do	10	......	1	60		New growth burned.	
Canna	½	......	1	64		No burning	
Carnation	1	......	1	54	Greenhouse thrips.	do	Do.
*Do	5	......	1	73		Tender foliage burned.	
Centaurea	½	......	1	60	Onion thrips	No burning	95 per cent killed.
Cereus (night-blooming)	2½	......	1	63		do	
Chrysanthemums:							
Single-stem var	½	......	1	62	Aphids	do	100 per cent killed.
Do	¾	......	1	68	do	do	Do.
Pompon var	½	......	1	62	do	do	Do.
Do	1	......	1	67	do	do	Do.
Cigar plant	¾	......	1	68	do	do	Do.
Cineraria	¾	......	1	60	do	do	Do.
Clerodendron	......	5	¾	66		do	

TABLE II.—*Results of fumigation with hydrocyanic-acid gas in greenhouses and boxes*—Continued.

[Plants with an * were fumigated in a box.]

Name of plant.	Rate in ounces per 1,000 cubic feet.		Exposure in hours.	Greenhouse temperature.	Infestation.	Results of treatment.	
	Sodium cyanid.	Potassium cyanid.				On plants.	On insects.
				°*F.*			
Cockscomb	½	......	1	64		No burning	
Coleus	¾	......	1	66	Greenhouse Orthezia.	do	100 per cent killed.
Columbine	5	......	1	59		do	
Coreopsis	½	......	1	62		do	
Cosmos	½	......	1	60		Tips burned	
Croton	¾	......	1	56	Long scale	No burning	Do.
Do	5	......	1	52	Immature citrus mealybug.	do	Do.
*Do	10	......	¾	68	Long scale	do	Do.
Cycas circinalis	2½	......	1	63	Florida red scale	do	Do.
Cyclamen	¾	......	1	68		do	
*Do	10	......	1	60		Flowers killed	
Daffodil	¾	......	1	55		No burning	
Deutzia gracilis	......	1⅘	½	......	Aphids	do	Do.
Digitalis	½	......	1	62		do	
Dioscorea pentaphylla	½	......	1	64		do	
Dracaena knerki	2½	......	1	63	Long-tailed mealybug.	do	Do.
Dracaena indivisa	......	5	¾	52		do	
Dusty miller	½	......	1	60		do	
Erica sp	½	......	1	64		do	
Eupatorium sp	¾	......	1	60		do	
Euphorbia sp	½	......	1	60		do	
Euonymus sp	½	......	1	60		do	
Ferns:							
Adiantum cuneatum	5	......	1	59		do	
Do	5	......	¾	62	Larvæ of Fla. fern caterpillar.	do	Do.
*Do	7½	......	¾	68	do	do	Do.
*Do	10	......	¾	68	do	New growth burned.	Do.
Adiantum croweanum	5	......	1	59		No burning	
Adiantum gracilium	½	......	1	57	Fern aphid	do	Do.
Adiantum trapeziforme.	½	......	1	57	do	do	Do.
Adiantum cardiocheleana.	2½	......	1	63		do	
Aspidium tsus-sinense	2½	......	1	59		do	
Asplenium nidus-avis.	¾	......	1	68		do	
Cyrtomium rochfordianum.	2½	......	1	59		do	
Cyrtomium falcatum	¾	......	1	60		do	
Lastraea chrysoloba	¾	......	1	68		do	
Nephrolepis bostoniensis.	2½	......	1	63	Aspidistra scale	do	Do.
*Do	5	......	¾	62	Larvæ of Fla. fern caterpillar.	do	Do.
*Do	7½	......	¾	68	do	do	Do.
*Do	10	......	1	68	do	New growth burned.	Do.
*Do	......	5	½	76	Aspidistra scale	No burning	All stages except eggs killed.
Nephrolepis scottii	2½	......	1	59		do	
Nephrolepis whitmanii.	2½	......	1	59		do	
Do	5	......	¾	66	Larvæ of Fla. fern caterpillar.	do	100 per cent killed.
Polystichum setosum.	¾	......	1	60		do	
Pteris wilsoni	2½	......	1	63		do	
Pteris wimsetti	2½	......	1	63		do	
Ficus elastica	2½	......	1	59	Florida red scale	do	Do.
Ficus pandurata	2½	......	1	63	Long-tailed mealybug.	do	Do.
Ficus utilis	2½	......	1	63		do	
Forgetmenot	½	......	1	56		do	
Do	5	......	1	52		Tips burned	
Forsythia viridissima	......	1⅘	½	......	Aphids	No burning	Do.
Freesia	¾	......	1	60		do	
Fuchsia	½	......	1	60	Aphids	do	Do.

Table II.—*Results of fumigation with hydrocyanic-acid gas in greenhouses and boxes*—Continued.

[Plants with an * were fumigated in a box.]

Name of plant.	Rate in ounces per 1,000 cubic feet.		Exposure in hours.	Greenhouse temperature.	Infestation.	Results of treatment.	
	Sodium cyanid.	Potassium cyanid.				On plants.	On insects.
				°*F.*			
Fuchsia	½	......	1	60	Greenhouse white fly.	No burning	All stages except eggs and late pupæ killed.
Do	5	......	1	58		Tips burned	
Gaillardia sp	½	......	1	62		No burning	
Gardenia	5	......	1	60		.....do	
Do	......	7½	1	......		Slight burning	
Genista	¾	......	1	55	Red spider	No burning	No killing.
Do	5	......	1	52	.....do	Flowers and new growth burned.	100 per cent killed.
Geraniums:							
Bedding	½	......	1	60	Greenhouse white fly.	No burning	All stages except eggs and late pupæ killed.
Do	5	......	1	60		New growth burned.	
Peppermint	¾	......	1	68		No burning	
Rose	½	......	1	64		New growth burned.	
Gladiolus	¾	......	1	55		No burning	
Heather (Scotch)	¾	......	1	68		.....do	
Do	......	5	¾	52		Slight burning	
Heliotrope	¾	......	1	60		No burning	
Do	5	......	1	58		Tips burned	
Hibiscus sp	¾	......	1	55		No burning	
Hyacinth (Roman)	2	......	1	56		.....do	
Hyacinth (water)	¾	......	1	55		.....do	
Hydrangea	¾	......	1	60		.....do	
Impatiens sultani	¾	......	1	68	Aphids	.....do	100 per cent killed.
Ipomoea grandiflora	¾	......	1	60		Open flowers burned.	
Ivy (English)	5	......	1	48	Fla. red scale	No burning	96 per cent killed.
Ivy (German)	¾	......	1	58	Spanish red scale.	.....do	100 per cent killed.
Iris (Spanish)	½	......	1	64		.....do	
Do	......	5	¾	66		Tips burned	
Jerusalem cherry	½	......	1	60	Aphids	No burning	Do.
Lantana	½	......	1	60	Orthezia	.....do	90 per cent killed.
Do	¾	......	1	56		.....do	
Laurus nobilis	5	......	1	54	Soft brown scale. Laurel scale Long-tailed mealybug.	...... No burning	95 per cent killed. 98 per cent killed. 100 per cent killed.
Do	......	7½	1	......	Soft brown scale.	No burning	90 per cent killed.
Lillies:							
Calla	½	......	1	64		.....do	
Do	......	5	¾	65		.....do	
Lilium formosum	½	......	1	60	Aphids	.....do	100 per cent killed.
Do	¾	......	1	60		.....do	
Lilium multiflorum	½	......	1	60	Aphids	.....do	Do.
Do	¾	......	1	60		.....do	
Lilium speciosum rubrum.	½	......	1	58	Aphids	.....do	No killing.
Lobelia	5	......	1	59		Tips burned	
Marguerite	½	......	1	70	Aphids	No burning	100 per cent killed.
Do	½	......	1	60	Immature hemispherical scale.	.....do	95 per cent killed.
Do	¾	......	1	68		.....do	
Marigold (French)	¾	......	1	64		.....do	
Mignonette	½	......	1	60		.....do	
Do	5	......	1	52		Tips burned	
Mimulus moschatus	¾	......	1	56		No burning	
Narcissus poeticus	¾	......	1	55		.....do	

TABLE II.—*Results of fumigation with hydrocyanic-acid gas in greenhouses and boxes*—Continued.

[Plants with an * were fumigated in a box.]

Name of plant.	Rate in ounces per 1,000 cubic feet.		Exposure in hours.	Greenhouse temperature.	Infestation.	Results of treatment.	
	Sodium cyanid.	Potassium cyanid.				On plants.	On insects.
				°F.			
Narcissus barri	¾	......	1	55		No burning	
Nasturtium	¾	......	1	55		do	
Nigella sp	½	......	1	62	Aphids	do	100 per cent killed.
Nymphaea sp	2½	......	1	63		do	
Orchids:							
Angraecum eburneum.[1]	½	......	1	60		do	
*Do.[1]	5	......	1	62	Diaspis sp	Slight burning	Do.
Brassea verrucosa.[1]	½	......	1	57		No burning	
Calanthe (hybrid)[1]	½	......	1	58		do	
Cattleya mossiae[1]	½	......	1	60		do	
Cattleya trianae[1]	½	......	1	57	Thrips	do	All stages except eggs killed.
Cattleya trianae[2]	20	......	¾	70		do	
Cattelya sp[2]	......	20	½	......		do	
Do	......	21	1	......		do	
Do	......	42	½	......		Slight burning, plant recovered.	
Chysis aurea	½	......	1	57		No burning	
*Coelia baueri	5	......	1	62		do	
Coelogyne cristata	⅓	......	1	57		Few old leaves burned.	
*Coelogyne flaccida	5	......	1	62	Chaff scale	No burning	100 per cent killed.
Coelogyne massangeana.	½	......	1	60		do	
Coelogyne speciosa	½	......	1	57		do	
Cymbidium pendulum.	½	......	1	57		do	
Cypripedium callosum.	½	......	1	60	Thrips	do	All stages except eggs killed.
Cypripedium calypso	½	......	1	60	do	do	Do.
Cypripedium spicerianum.	½	......	1	60	do	do	Do.
Cypripedium venustum.	½	......	1	57	do	do	Do.
*Cypripedium sp	5	......	1	62		do	
Dendrobium ainsworthi.	½	......	1	57		do	
Dendrobium aggregatum.	½	......	1	57		do	
*Dendrobium fimbriatum.	5	......	1	62	Lepidosaphes sp.	do	100 per cent killed.
Dendrobium grandiflorum.	½	......	1	57		do	
Dendrobium nobile	½	......	1	60		do	
Dendrobium parishii	½	......	1	57		do	
Epidendrum prismatocarpum.	½	......	1	57		do	
Laelia anceps	½	......	1	57		do	
Laelia acuminata	½	......	1	57		do	
Laelia superbiens	½	......	1	60		do	
Maxillaria graminifolia.	½	......	1	57		do	
Oncidium embratium	½	......	1	60		do	
Oncidium papiliomajus.	½	......	1	60		do	
Oncidium sphacelatum.	½	......	1	57		do	
Oncidium splendidum	½	......	1	57		do	
Odontoglossum sp	½	......	1	58		do	
Phalaenopsis schilleriana.	½	......	1	60		do	
Pholidota imbricata	½	......	1	57		do	

[1] Orchids in growing condition, practically all having new growth, flower bud, or blossom.
[2] Imported orchids without new growth

TABLE II.—*Results of fumigation with hydrocyanic-acid gas in greenhouses and boxes*—Continued.

[Plants with an * were fumigated in a box.]

Name of plant.	Rate in ounces per 1,000 cubic feet.		Exposure in hours.	Greenhouse temperature.	Infestation.	Results of treatment.	
	Sodium cyanid.	Potassium cyanid.				On plants.	On insects.
Orchids—Continued.				°F.			
Schomburgkia tibicinis.	½	......	1	57	....	No burning.....	
Schomburgkia undulata.	5	......	1	62	....	.....do..........	
Sobralia macrantha...	½	......	1	58	....	.....do..........	
Thunia marshalliana.	½	......	1	58	....	.....do..........	
Vanda caerulea.......	½	......	1	58	....	.....do..........	
Palms:							
Areca lutescens	2½	......	1	63	Palm mealybug, tessellated scale.	.....do..........	100 per cent killed.
*Do..............	......	10	1	65	Tessellated scale.	.....do..........	Do.
Cocos plumosa........	2½	......	1	59	Tessellated scale, palm mealybug.	.....do..........	Do.
Kentia belmoreana...	2½	......	1	59	Palm aphid, palm mealybug, thread scale, Florida red scale.	Slight burning of some new growth.	Do.
*Kentia belmoreana..	......	5	½	......	Palm mealybug, palm aphid.	No burning.....	Do.
Kentia fosteriana.....	2½	......	1	59	Palm aphid, Florida red scale, thread scale.	Slight burning of some new growth.	Do.
Latania borbonica....	2½	......	1	63	Thread scale....	No burning.....	Do.
Phoenix roebeleni....	2½	......	1	63	Thread scale, tessellated scale.	.....do..........	Do.
*Phoenix sp..........	......	10	1	73	....	.....do..........	
Rhapis flabilliformis..	2½	......	1	59	Palm mealybug, tessellated scale.	.....do..........	Do.
Pandanus graminifolius.	¾	......	1	68	....	.....do..........	
Pandanus veitchi.......	¾	......	1	68	....	.....do..........	
*Do..................	......	10	1	73	Florida red scale	.....do..........	Do.
Pansy.................	½	......	1	62	Aphids..........	.....do..........	Do.
Do....................	5	......	1	52	....	.....do..........	
Pelargonium sp.........	¾	......	1	68	Aphids..........	.....do..........	75 per cent killed.
Pentstemon sp..........	......	5	¾	52	....	.....do..........	
Do....................	......	7½	1	......	....	Slight burning..	
Petunia................	½	......	1	60	....	No burning.....	
Poinsettia..............	½	......	1	62	....	.....do..........	
Poppy (Shirley)........	½	......	1	60	....	.....do..........	
Poppy (water).........	2½	......	1	60	....	.....do..........	
Primula (Chinese)......	¾	......	1	56	....	.....do..........	
Do....................	......	5	¾	66	....	.....do..........	
Primula malacoides.....	¾	......	1	55	....	.....do..........	
Primula obconica.......	¾	......	1	55	....	.....do..........	
Rhododendron.........	......	5	¾	66	....	.....do..........	
Rosemary..............	½	......	1	64	....	.....do..........	
Roses (seven commercial varieties).	⅜	......	1	49	....	.....do..........	
Do....................	½	......	1	56	....	New growth burned.	
Sansevieria............	2½	......	1	63	....	No burning.....	
Scarlet sage...........	¾	......	1	60	....	.....do..........	
Schizanthus sp.........	¾	......	1	56	....	.....do..........	
Smilax.................	5	......	1	48	....	New growth burned.	
Snapdragon............	½	......	1	60	....	New growth and floral spikes burned.	

TABLE II.—*Results of fumigation with hydrocyanic-acid gas in greenhouses and boxes*—Continued.

[Plants with an * were fumigated in a box.]

Name of plant.	Rate in ounces per 1,000 cubic feet.		Exposure in hours.	Greenhouse temperature.	Infestation.	Results of treatment.	
	Sodium cyanid.	Potassium cyanid.				On plants.	On insects.
				°F.			
Spiraea sp	3/4		1	60		No burning	
Stephanotis floribunda		5	3/4	60		do	
Stevia	1/2		1	60		do	
Stocks	1/2		1	62		do	
Swainsona sp	3/4		1	60		do	
Sweet peas	1/2		1	60	Aphids	Tips and blossoms burned.	100 per cent killed.
Sweet William	1/2		1	56		No burning	
Thunbergia erecta	1/2		1	64		do	
Tulip	3/4		1	55		do	
Umbrella plant	2 1/2		1	63	Red spider	do	Do.
Verbena (hardy)	3/4		1	60		do	
Verbena (lemon)	1/2		1	64		New growth burned.	
Vinca major variegata	3/4		1	56		No burning	
Do		5	3/4	66		do	
Vinca rosea	3/4		1	60		do	
Violet	5		1	48	Aphids	do	Do.
Wandering Jew	1/2		1	64		Severe burning	

In order that there may be no confusion on the part of the reader as to the insects referred to in the tables by their common names, both their common and scientific names are listed herewith:

Greenhouse white fly	*Trialeurodes vaporariorum* (Westw.).
Citrus mealybug	*Pseudococcus citri* (Risso).
Long-tailed mealybug	*Pseudococcus adonidum* (L.).
Palm or avocado mealybug	*Pseudococcus nipae* (Mask.).
Greenhouse Orthezia	*Orthezia insignis* (Dougl.).
Florida red scale	*Chrysomphalus ficus* (Ashm.).
Long scale	*Coccus elongatus* (Sign.).
Soft brown scale	*Coccus hesperidum* (L.).
Palm aphis	*Cerataphis lataniae* (Boisd.).
Hemispherical scale	*Coccus hemispherica* (Targ.).
Florida fern caterpillar	*Eriopus floridensis* (Guen.).
Aspidistra scale	*Hemichionaspis aspidistrae* (Sign.).
Tessellated scale	*Eucalymnatus tessellatus* (Sign.).
Azalea Eriococcus	*Eriococcus azaleae* (Horv.).
Azalea lacewing	*Stephanitis azaleae* (Horv.).
Greenhouse thrips	*Heliothrips haemorrhoidalis* (Bouché).
Thread scale	*Ischnaspis longirostris* (Sign.).
Chaff scale	*Parlatoria proteus* (Curt.).
Spanish red scale	*Chrysomphalus dictyospermi* (Morg.).

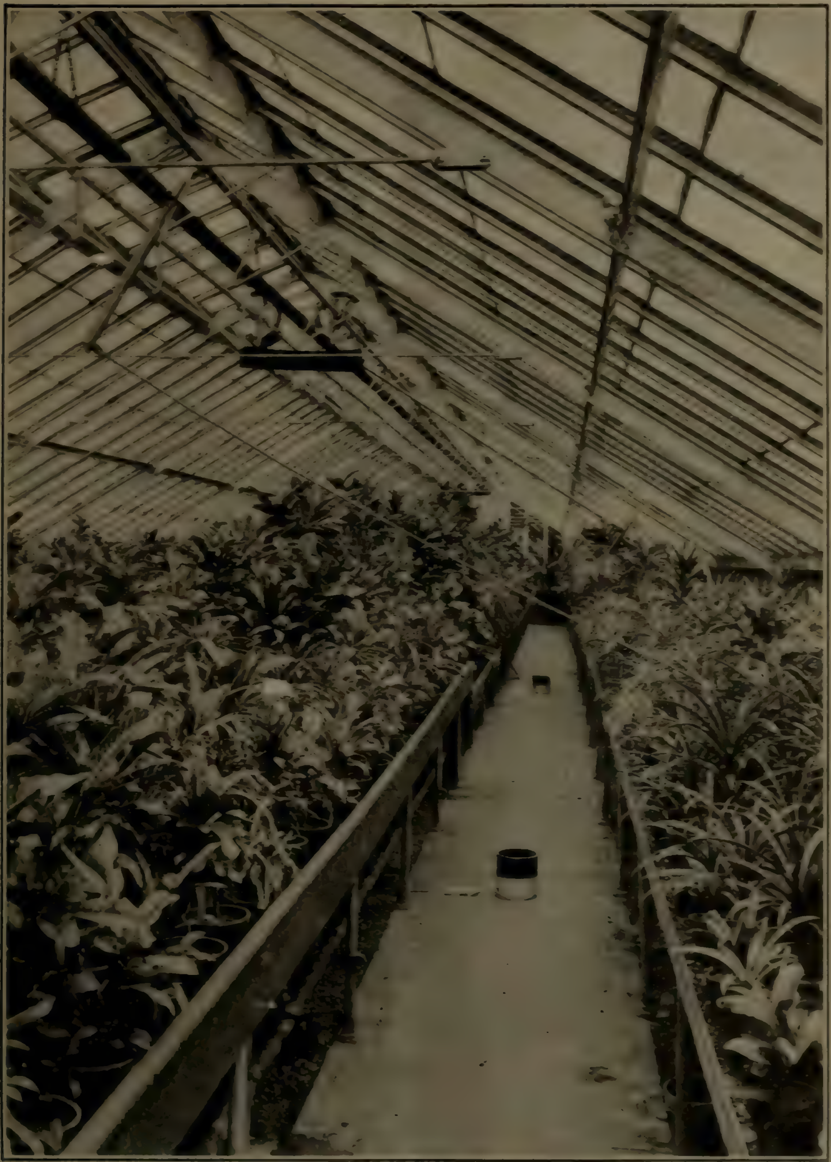

FIG. 4.—Greenhouse ready for fumigation.

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PRESERVATION OF VEGETABLES BY FERMENTATION AND SALTING

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UNITED STATES DEPARTMENT OF AGRICULTURE

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and Bureau of Chemistry, C. L. Alsberg, Chief

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AMONG the practical methods of conserving surplus food, especially worthy of consideration at this time, are those based on preservation by fermentation and salting or brining.

Owing to the enormous development of canning in this country during the last generation and the ease with which fresh vegetables may be obtained from some part of the country at almost any time of year, relatively little use has been made of these methods of preserving, which were used by our forefathers and which are still used in Europe to a considerable extent. In this country the only substances commonly prepared by fermentation are sauerkraut and salt cucumber pickles, and, as a domestic product in some regions, "salted beans." Many other vegetables, however, lend themselves very readily to this method of preservation and furnish products quite different from the original substances, but which are none the less wholesome and appetizing and are greatly liked by many people. They also offer variety in the diet, which is an important consideration.

The object of this bulletin is to describe and explain methods of preservation by fermenting and salting, to indicate the purposes to which they are especially applicable, and to tell how the preserved products can best be prepared for table use.

The methods are not given with the view that they will be substituted for canning or drying, but simply for the purpose of making housekeepers more familiar with additional methods of preserving foods which they may use if they so desire.

PRESERVATION OF VEGETABLES BY FERMENTATION AND SALTING.

CONTENTS.

	Page.
Advantages of the methods	3
General principles of the methods	3
Equipment needed	4
Fermentation with dry salting	5
Fermentation in brine	9
Salting without fermentation	11
Care and storage of fermented and salted products	12
Preparation of fermented and salted vegetables for the table	12

ADVANTAGES OF FERMENTATION AND SALTING METHODS.

METHODS of preserving vegetables by salting or fermenting them have been practiced for a long time, and vegetables so prepared are known to be wholesome food. Recent experiments by the Department of Agriculture have shown that a great many vegetables may be satisfactorily preserved by such methods which deserve a wider use in the home than they have had in the past. One advantage that these methods possess is that they make use of containers which could not be used for canning. For example, old kegs, lard and butter tubs, stone crocks or jars, wide-mouthed glass jars, and glass preserving jars without covers, if thoroughly cleaned, may be used for the storage of salted or fermented vegetables. Another advantage is that with a given amount of labor, a great deal more material can be cared for by these methods than could be preserved in the same time if canning or drying alone were depended upon.

GENERAL PRINCIPLES OF THE METHODS.

The methods of preservation considered in this bulletin group themselves naturally under three heads: (1) Fermentation with dry salting, (2) fermentation in brine, and (3) salting without fermentation.

When vegetables are either packed dry with 2 or 3 pounds of salt to every 100 pounds of material, as in the making of sauerkraut, or are covered with a brine containing 5 pounds of salt to every 12 gallons of water, as in the preparation of dill pickles, the sugars present in the vegetables are extracted from them and are fermented by the lactic-acid-forming bacteria which are present naturally in great numbers on the surface of the fresh material. After this action has gone on to a certain point, enough of this lactic acid is formed to kill the bacteria and prevent any further change in the material, provided certain precautions are taken to prevent the growth of molds. The lactic acid permeates the fermented material and gives it a characteristic flavor not unlike that of a weak vinegar solution. This flavor is relished by many. The lactic acid has no harmful effect. It is the same acid which is present in sour milk and it is digested and utilized by the body as a source of energy.

If the vegetables are covered with a very strong brine, or are packed with a fairly large amount of salt, lactic-acid fermentation and also the growth of other forms of bacteria and molds are prevented. This method of preservation is especially applicable to those vegetables which contain so little sugar that sufficient lactic acid can not be formed by bacterial action to insure preservation of the material.

In the well-known method of vinegar pickling, the acetic acid of the vinegar acts like the lactic acid produced by fermentation as a preservative, preventing the growth of bacteria or molds. Sometimes brining precedes pickling in vinegar, and often the pickling is modified by the addition of sugar and spices, which add flavor as well as help to preserve the fruit or vegetables. In some cases olive oil or some other table oil is added to the vinegar, as in the making of oil cucumber pickles.

EQUIPMENT NEEDED.

A supply of clean wooden kegs or stone crocks is the first requisite. For home use the smaller sizes are preferable as a rule, because the contents will then be used up more quickly and there will be less chance of molding from standing too long after the kegs or crocks are opened. Wooden kegs holding 5 or 10 gallons are a convenient size. New kegs are preferable, but old ones, such as beer or cider kegs, may be used if they are thoroughly washed and steamed to remove any undesirable odor or flavor which might be imparted to the foods packed in them. Wooden vessels of yellow or pitch pine are undesirable, since they are apt to give a disagreeable taste to the foods. Stone crocks or jars holding from 1 to 5 gallons are convenient. Stoneware is less likely to absorb flavors than wood, and stone jars may be obtained in smaller sizes than wooden kegs. Wide-mouthed bottles or glass jars, which are not suitable for canning, may also be used for salting or fermenting small quantities of foods.

A supply of ordinary fine salt, which can be purchased in bulk for about 2 cents per pound, is most satisfactory for general use. Table salt will do very well, but is rather expensive if large quantities of vegetables are to be preserved. The rather coarse salt (known in the trade as "ground alum salt"), which is used in freezing ice cream, can be used. Rock salt should not be used because it is too coarse and is likely to contain impurities.

Clean white cloth (cheesecloth or muslin) is necessary for covering the material after it is packed into the container. It will be found convenient to cut this into circular pieces about 6 inches larger in diameter than the stone crock or keg. Two or three thicknesses of cheesecloth or one thickness of muslin or heavier cloth should be spread over the top of the vegetables.

Round pieces of board about 1 inch or more in thickness will be needed to put on top of the cheesecloth. The boards should be a little smaller in diameter than the inside of the crock or the head of the keg or tub, so that they will slip in and out easily. The pieces may be sawed out at a lumber mill, or may be made at home by fastening together several boards with cleats and rounding them with a small saw and a carpenter's shave. Almost any wood may be used except yellow or pitch pine, which is likely to impart an undesirable flavor to the vegetables. For small containers, if preferred, heavy plates of suitable size can be used instead of boards.

One or more clean bricks or some clean stones may be used as weights to hold down the mass in the keg or crock.

Paraffin is needed to pour over the liquid in the containers (after fermentation has ceased) to prevent mold.

A pair of kitchen scales or steelyards and a quart or gallon liquid measure completes the necessary equipment.

FERMENTATION WITH DRY SALTING.

As has already been stated, fermentation with dry salting consists in packing the material with a small amount of salt. No water is added, for the salt extracts the water from the vegetables and forms the brine. The method, in general, is as follows:

Wash the vegetables, drain off the surplus water, and weigh them. For each 100 pounds of the vegetables weigh out 3 pounds of salt: for smaller quantities use the same proportion (3 per cent by weight) of salt. Cover the bottom of the keg, crock, or other container with a layer of the vegetables about 1 inch thick and sprinkle over this a little of the salt. Do not add too much of the salt to the first layers packed, but try to distribute it equally among the different layers so that the quantity which has been weighed out will be sufficient for the given quantity of vegetables packed. If a little of the salt is left over, it can be added to the top layer, but if more has to be added than has been weighed out, the finished product will taste too salty. Continue adding layers of the material sprinkled with salt until the container is about three-fourths full. Sprinkle the last of the salt on the top layer and spread over it one or two thicknesses of cheesecloth, tucking them down at the sides. On the cloth place one of the round pieces of board or a plate, mentioned on page 5, and on this put a clean stone or one or two clean bricks. The size of the weight depends on the quantity of material being preserved. For a 5-gallon keg a weight of 10 pounds will be sufficient, but if a larger barrel is used, a heavier weight will be needed. The weight added should be sufficient to extract the juices to form a brine, which will cover the top in about 24 hours and sometimes it may be necessary to add more stones after the material has stood a while, if a brine does not form. The method of packing the vegetables is illustrated by figure 1.

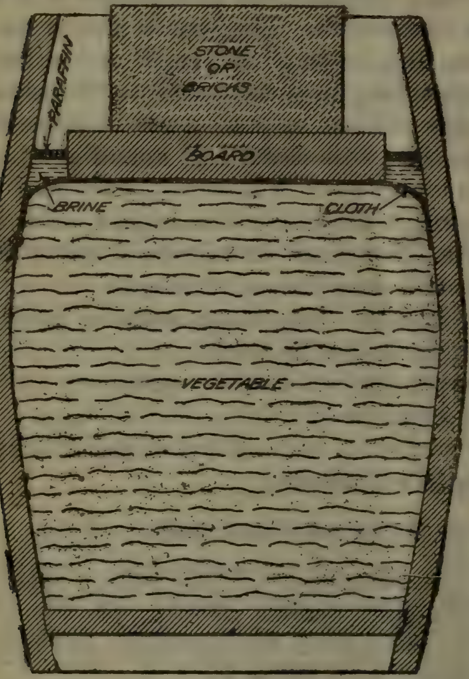

Fig. 1.—Diagram illustrating method of packing vegetables into keg or other container for fermenting or salting.

After it is packed, allow the container to stand in a moderately warm room to ferment. The salt and pressure of the weight soon extract water from the vegetables and form a brine which soon covers the whole mass. The stone and board serve to keep the vegetables beneath the surface of the liquid. If the weight is not sufficient for this purpose, a larger stone or more bricks should be added. As the fermentation goes on, bubbles arise to the surface of the liquid. The rate of fermentation depends principally upon the temperature. In warm weather it requires only 8 to 10 days; in cool weather 2 to 4 weeks may be necessary. When bubbling stops, fermentation is complete. A good way to determine this is to tap the receptacle gently; if no bubbles arise, fermentation is finished.

The containers should then be placed in a cellar or other cool storeroom and the surface of the liquid treated to prevent the development of a scum of mold. If this is not done a thin film will appear on the surface of the brine soon after fermentation ceases, which will spread rapidly and develop into a heavy folded membrane. This scum is a growth of microorganisms which feed upon the acid formed by fermentation. If allowed to grow undisturbed, all the acid will eventually be destroyed and the fermented material will spoil. This scum must be prevented from forming if the product is to be kept for a considerable time. Exclusion of air from the surface of the brine will entirely prevent its formation. There are three feasible methods of accomplishing this.

The first method is to cover the surface with very hot melted paraffin. If the paraffin is sufficiently hot to make the brine boil when poured upon it, a smooth, even layer will be formed before hardening, making a perfectly air-tight seal. Before adding paraffin the containers should be set where they will not be disturbed until ready for use, as any attempt to move them afterwards may break the seal and necessitate resealing. Paraffin has the advantage of ease in handling, and of being easily separated from the fermented vegetables when they are removed. Further, it can be used over again and thus the expense is small in the long run. If it becomes dirty it can be purified by heating very hot and straining through several thicknesses of cheesecloth. One disadvantage in the use of paraffin is that the formation of gas below the layer will break the seal; therefore it should not be used until fermentation has ceased. If the paraffin breaks, it should be removed, remelted, and replaced.

The second method is to pack a barrel or keg full and then replace the head. Fill the barrel or keg as full as possible with the fresh material to be fermented and then add the round board and weights exactly as described on page 6. Let the barrel stand for 48 hours to allow part of the gas to escape. Then remove the board and weight and head the barrel or keg up tight. Bore a small hole (about one-half inch) in the head and fill the barrel full with brine (made by dissolving three-fourths cup salt in 1 gallon water) so that there is no air space. Allow the barrel to stand until the fermentation has stopped, adding more brine at intervals to keep the container full. When bubbling has stopped, plug the vent tight. If the barrel does not leak, fermented products put up in this manner will keep indefinitely.

The third method is to use an oil, like cottonseed oil, which floats on the surface and effectively prevents air from reaching the brine. Brine covered with a layer of cottonseed oil or some other wholesome oil about one-quarter inch thick will keep indefinitely. The only objection to liquid oils is the difficulty of getting at the preserved vegetables without getting them covered with the oil, which is difficult to remove. Before the vegetables are to be removed the oil should be skimmed or siphoned off from the surface of the brine.

If oil or paraffin is used to cover the brine, it is advisable, after fermentation is finished, to adjust the amount of brine used and weights on the cover so that the brine comes up to but not over the cover. In this case only the brine exposed between the cover and sides need be oiled or paraffined, thus saving covering material.

Experiments by the department have shown that the following vegetables may be preserved successfully under home conditions by the above method of fermentation by dry salting: Cabbage (sauerkraut), string beans, beet tops, and turnip tops, and it is probable that others may be added to this list as a result of further experiments. In general the method described above should be followed for all vegetables preserved by this method, with modifications in the preservation of some of them as follows:

SAUERKRAUT OR FERMENTED SALT CABBAGE.

In many parts of the country it is a general belief that only late or fall cabbage is suitable for making sauerkraut. Such, however, is not the case. If properly handled and stored, sauerkraut of excellent quality can be produced from cabbage maturing at any season of the year. The essential points are the use of only mature, sound cabbage, scrupulous cleanliness throughout the process, and proper care of the surface of the brine after fermentation is completed.

In making sauerkraut for home purposes the outer green leaves of the cabbage should be removed, just as in preparing the head for boiling. In addition all decayed or bruised leaves should be discarded and the core removed. If an instrument for this purpose is not available, it is advisable to quarter the heads and slice off the part of the core remaining on each quarter. The cabbage should be shredded by one of the hand-shredding machines sold upon the market for such purposes, or if one is not available the heads may be cut into thin slices with a slaw cutter or a large knife.

The shredded cabbage should be packed immediately into a perfectly clean, water-tight receptacle, such as a cider or wine barrel, keg, or tub. As it is packed into the receptacle add salt in the proportion of 1 pound of salt to 40 pounds of cabbage, distributing it evenly throughout the cabbage, as described on page 5. Experiments have shown that approximately 2½ pounds of salt to each 100 pounds of shredded cabbage give the best flavor to the resulting kraut. When the barrel or crock is nearly full the cabbage should be pressed down as firmly as possible and covered with a clean board cover. It is advisable but not essential that clean cloth be placed over the cabbage before the cover is put into place. The salt soon extracts a considerable amount of the cabbage juice from the cabbage, and a sufficient weight of clean brick or stone should be added to cause the brine to rise up to the wooden cover. Set the container aside until fermentation is complete, skim off any scum that forms and protect the surface by pouring over it a layer of paraffin, as described on page 7. If paraffin is not added, the scum develops very rapidly during warm weather and soon destroys the acid of the brine and the sauerkraut beneath. If the sauerkraut is made during the fall and stored in a cool place, there is no absolute necessity of a layer of paraffin, since the low temperature will prevent the growth of the organism which destroys lactic acid and causes decomposition. No doubt the popular idea that sauerkraut made from early cabbage will not keep is based upon the fact that the fermentation of sauerkraut made from such cabbage occurs in warm weather and the rapid growth of scum soon destroys both brine and kraut if the surface is not properly protected.

STRING BEANS.

String beans should be young and tender and not overgrown. Remove the tip ends and strings, cut or break the beans into pieces about 2 inches long, and pack as described on page 5. If desired, the beans may be shredded by cutting lengthwise several times, and the fermented product prepared like sauerkraut.

BEET TOPS AND TURNIP TOPS.

Wash to remove grit and follow general directions as described on page 5.

FERMENTATION IN BRINE.

As stated above, some vegetables which do not contain sufficient water are better fermented by covering them with a weak brine.

Wash the vegetables, drain off the surplus water, and pack them in a keg, crock, or other utensil until it is nearly full (within about 3 inches of the top of the vessel). Prepare a weak brine as follows: To each gallon of water used add one-half pint of vinegar and three-fourths of a cup of salt and stir until the salt is entirely dissolved. The amount of brine necessary to cover the vegetables will be about equal to one-half the volume of the material to be fermented. This is very easily calculated by knowing the contents of the container used. For example, if a 5-gallon keg is to be packed, 2½ gallons will be needed. It is best to make up at one time all the brine needed on one day. A clean tub or barrel can be used for mixing the brine. Pour the brine over the vegetables and cover as described on page 5. Set the vessel and its contents away in a moderately warm room to ferment. When fermentation has stopped, the container should be placed in a cool cellar or storeroom and the surface of the liquid treated to prevent mold by one of the methods described above. Before adding the paraffin or cottonseed oil, any scum or mold which may have formed on the surface of the liquid should be removed by skimming.

Experience has shown that the following vegetables may be preserved satisfactorily by fermenting in brine: Cucumbers, string beans, green tomatoes, beets, beet tops, turnip tops, corn, and green peas. The general directions given above should be followed, but some modifications are desirable in the preserving of individual vegetables by this method, and these are given in the following pages.

CUCUMBERS.

Wash the cucumbers and pack into a clean, water-tight keg or crock. On the bottom of the container place a layer of dill and a handful of mixed spice. When the container is full add more dill and spice. Add sufficient brine to cover the material. When nearly full cover with a clean cloth and a board cover weighted with stone, as described on page 5. The dill and spices may be omitted if desired.

STRING BEANS.

Remove the ends and strings from the beans and cut into pieces about 2 inches long, pack in the container, cover with brine, and ferment, as described on page 9.

GREEN TOMATOES.

Green tomatoes should be packed whole and prepared as cucumbers. The dill and spice may be added if desired.

BEETS.

Beets must be scrubbed thoroughly and packed whole. If peeled or sliced before being fermented the beets lose considerable color and flavor.

BEET TOPS AND TURNIP TOPS.

These should be washed thoroughly and packed into the container without being cut up.

PEAS.

Green peas should be shelled and packed in the same way as string beans. It is advisable to use fairly small containers for peas so that the quantity opened up will be used before it has a chance to spoil.

CORN.

Husk and clean the silk from the corn; wash and place the ears on end in the jar, packing the jar nearly full. Pour the brine over the ears; add cover and weights. Fermented corn has a sour taste, which may not be relished if the corn is eaten alone. For this reason it will be preferable in most cases to preserve corn by canning, drying, or by salting, as described on page 11. Fermented corn, however, may be used in the preparation of some dishes, such as chowders, omelets, etc., where its flavor will be masked to some extent by the other ingredients, and the acid taste of the fermented corn may not be objectionable to some people.

SALTING WITHOUT FERMENTATION.

In this method the vegetables are packed with enough salt to prevent fermentation or the growth of yeasts or molds. The following directions should be followed in salting vegetables:

Wash the vegetables, drain off the water, and then weigh them. For each 100 pounds of vegetables weigh out 25 pounds of salt. For smaller quantities use the same proportion of salt (one-fourth of the weight of the vegetables). Spread a layer of the vegetables about 1 inch deep on the bottom of a clean keg, tub, or crock, and sprinkle heavily with some of the salt. Try to distribute the salt evenly among the different layers packed so that the quantity weighed out will be just enough to pack the vegetables. Continue adding layers of vegetables and salt until the container is nearly full and then cover with the clean cloth, board, and weight, as in the case of fermentation by dry salting. The keg or other container should then be set aside in a cool place. If the salt and pressure of the weight have not extracted sufficient brine to cover the vegetables, after 24 hours, prepare a strong brine by dissolving 1 pound of salt in 2 quarts of water and pour enough of this over the vegetables to come up to the round wooden cover. There will be a small amount of bubbling at the start, as in the case of the fermented vegetables, but this will not continue for long. Just as soon as the bubbling has stopped the surface of the liquid should be protected by one of the methods described on page 7.

Experiments have shown that the following vegetables may be satisfactorily preserved by the above method: Dandelions, beet tops, turnip tops, spinach, chard, kale, cabbage, string beans, green peas, and corn. The string beans should be cut in 2-inch pieces, as in their preparation for fermentation. The peas should be shelled and packed according to the directions given above. Cabbage should be shredded and packed in the same way as in the manufacture of sauerkraut. Corn, however, requires somewhat different treatment and the directions for salting it are as follows:

SALTED CORN.

Husk the ears of corn and remove the silk. Cook in boiling water for about 10 minutes to set the milk. Cut off the corn from the cob with a sharp knife. Weigh the corn and pack in layers with one-fourth its weight of fine salt, as described above.

CARE AND STORAGE OF FERMENTED AND SALTED PRODUCTS.

If properly prepared and stored, fermented and salted products will keep for a long time. It is absolutely necessary to prevent mold from growing on the surface of the brine of fermented vegetables by the addition of paraffin or in some other way, as described on page 7. Protection of the surface of salted vegetables is desirable, but not necessary if the containers are covered to prevent the evaporation of the brine. Practically all of the trouble with the fermented or salted products may be traced to carelessness in protecting the surface of the brine. In case mold should develop upon the surface or the brine should become evaporated so that the upper layers of the food spoil, this does not mean necessarily that the entire contents of the vessel has spoiled, even though the upper layers may have a very disagreeable odor. The molds and other organisms which cause the spoiling do not penetrate rapidly to the lower layers, and by carefully removing the spoiled material from the top, adding a little fresh brine and pouring hot paraffin on the top, the remainder of the contents of the vessel may be saved. After fermentation has ceased, the containers of salted and fermented vegetables should be stored in a cool place. They should be protected from rats, mice, and vermin, which might eat through the paraffin layer and get at the contents.

PREPARATION OF FERMENTED AND SALTED VEGETABLES FOR THE TABLE.

Some fermented and salted vegetables, like cucumbers, are eaten raw; others, like cabbage (sauerkraut), are usually cooked. In general the fermented and salted products may be prepared for the table in much the same manner as the fresh vegetables, except that before being cooked they should be soaked in fresh water for several hours or longer, if necessary, to remove the salt, the water being changed several times. In some cases it may be necessary also to change the water once or twice during the boiling of the salted vegetables. In this one should be guided by taste.

Fermented vegetables, after being removed from the container, should be rinsed thoroughly in fresh water and then cooked without soaking if a product having a decidedly acid flavor is desired. If one does not desire the acid flavor, it may be modified to any extent or removed almost entirely by soaking the fermented vegetables as directed above for the salted product.

The following suggestions and recipes are given as a guide in the preparation of salted and fermented vegetables for the table. These have been tested and found to give satisfactory results.

DANDELIONS, SPINACH, KALE, AND OTHER GREENS.

The salted greens, after they have been soaked to remove the salt, may be boiled with fat meat or boiled plain and served with a cream sauce and garnished with hard-boiled eggs. When so prepared they taste much like the fresh greens, although, naturally, they lose some of their flavor during the salting and freshening processes.

The fermented greens may be soaked and cooked in the same way as the salted greens, but, in general, it is desirable to cook them without soaking and preserve the acid flavor, which is very similar to that of the fresh greens when boiled and served with vinegar.

BEETS.

Rinse the fermented beets and boil in the same manner as fresh beets. When thus prepared they have a flavor which is not unlike the common pickled beets and may be served as a pickle, with butter, or used in the preparation of salads, vegetable hashes, etc.

STRING BEANS.

The salted string beans should be soaked to remove the salt and then cooked in any of the ways in which fresh string beans are prepared. The fermented string beans may be cooked without soaking and served as a vegetable or as an ingredient of a salad, the acid flavor being agreeable to many persons. Young and tender string beans may be fermented and eaten raw in the same way as cucumber pickles.

CORN.

To prepare the fermented or salted corn for the table, rinse it thoroughly and soak it for four or five hours, changing the water frequently. In general it will be found more satisfactory to remove practically all of the acid flavor from the fermented corn. After soaking, place the corn in cold water and bring to boil, pour off the water, add fresh cold water, bring to boil again, and cook until tender. The cooked salted or fermented corn may be used in the following recipes which are given below, or may be served as stewed corn or succotash.

CORN CHOWDER.

¾ pound cold beef, or
¼ pound salt pork or bacon.
2 potatoes.
1 onion.
½ green pepper.
1½ cups cooked corn, or more.
1 cup tomatoes.
3 tablespoons flour.
1 cup milk or cream.
1 teaspoon salt.
¼ teaspoon pepper.

Cut the meat or pork into cubes; cover well with water. Add the tomato and cook slowly for about two hours. Then add the potato, onion, pepper, corn, and seasonings. Cook until the vegetables are tender. Mix the flour with a little cold water, add to the other ingredients, and cook slowly for 5 or 10 minutes. Add the milk or cream; serve hot.

SCALLOPED TOMATOES WITH CORN.

2 cups canned tomatoes.
1 teaspoon salt.
¼ teaspoon pepper.
2 tablespoons sugar.
1 cup bread crumbs.
2 cups salted or fermented corn.

Cover the bottom of the greased baking dish or casserole with a layer of bread crumbs; add a layer of the corn and one of tomatoes. Continue this until all materials have been used up, saving a layer of bread crumbs for the top. Dot with butter and brown in a hot oven.

CORN PUDDING.

2 eggs.
1 pint milk.
1 tablespoon sugar.
2 cups cold cooked corn.
2 tablespoons melted butter or other fat.
½ teaspoon salt.

Beat the eggs until light and add the sugar, corn, milk, melted butter, and salt. Pour into a buttered baking dish and bake in a slow oven until firm. Skim milk may be used in this dish.

CORN OMELET.

4 eggs.
½ teaspoon salt.
4 tablespoons hot water.
1 tablespoon butter.
1 cup cold cooked corn.

Separate yolks and whites of eggs. To the yolks add the salt, pepper, and hot water, beat until thick, and then add the corn. Fold the stiffly beaten whites into the first mixture. Cook the omelet slowly in a buttered pan until a delicate brown.

CORN FRITTERS.

2⅓ cups cooked corn.
1 cup flour.
1 teaspoon baking powder.
2 teaspoons salt.
¼ teaspoon paprika.
2 eggs.

Chop the corn. Mix and sift dry ingredients and add chopped corn and the well-beaten egg yolks, and then fold in the stiffly beaten whites. Bake on well-greased griddle or in frying pan until a golden brown. Drain on brown paper. Serve hot with butter or sirup.

CORN WAFFLES.

1¾ cups flour.
⅔ cup cooked corn.
1½ cups milk.
2 tablespoons sugar.
4 teaspoons baking powder.
¾ teaspoon salt.
1 tablespoon butter.
1 egg.

Mix and sift dry ingredients. Add the corn and mix thoroughly. Add the milk, yolk of egg well beaten, butter, and stiffly beaten egg white. Bake in greased hot waffle iron until golden brown.

PEAS.

Salted or fermented peas should be soaked to remove most of the salt or acid flavor, and may then be served in the same way as fresh green peas. The following recipes have been found satisfactory for using the salted or fermented peas:

PURÉE OF PEAS.

2 cups salted or fermented peas.
½ cup whole or skim milk.
1 teaspoon salt.
1 tablespoon butter or other fat.
Paprika.

Boil the peas until tender, press them through a sieve to remove skins, and put into a saucepan. Add ½ cup warm milk (or skim milk), 1 teaspoon salt, and a little paprika. Mix well and cook for five minutes. Serve hot.

PEA TIMBALES.

2 cups salted or fermented peas.
2 eggs.
2 tablespoons melted butter or other fat.
½ teaspoon salt.

Boil the peas until tender and rub through a sieve. Add the eggs well beaten, salt, a little pepper, and a few drops of onion juice. Turn into greased molds and cover them with greased paper. Set the molds in a pan of hot water and bake in the oven until firm. Serve with white sauce.

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IRRIGATION OF ORCHARDS

SAMUEL FORTIER

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SUPERSEDED BY 1518

FARMERS' BULLETIN 882

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Office of Public Roads and
Rural Engineering

LOGAN WALLER PAGE, Director

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ORCHARD IRRIGATION in the arid and semiarid regions of this country varies in practice, according to water supply, climate, soil, and situation of the land, and in cost of installation and maintenance of the system.

The right selection of land for an orchard tract should be the irrigator's first step toward profitable fruit production.

Expensive devices should not be used for distributing water in orchards of low value and small returns, but valuable orchards, yielding large annual returns will justify the best-known devices for successful irrigation.

Prevention of waste of water should be a chief object of the irrigator not alone for the sake of economy but for the good of the orchard as well.

A discussion of the factors essential to the successful irrigation of orchards, as well as of different methods used, is presented in the following pages.

IRRIGATION OF ORCHARDS.

CONTENTS.

	Page.
Selection of lands for orchards	3
Typical water supplies for orchards	4
Clearing and grading land for fruit	7
Locating the tree rows	9
Methods of irrigating orchards	12
Time to irrigate orchards	27
Number of irrigations per season	27
Duty of water in orchard irrigation	28
Evaporation losses from orchard soils	31
Loss of water due to percolation	35
Removal of waste water	37
Influence exerted by time of irrigation	38
Winter irrigation of orchards	40

SELECTION OF LANDS FOR ORCHARDS.

CARE and good judgment should be exercised in the selection of an orchard tract. If the enterprise turns out well, the profits are high, but if it fails, the losses are heavy. It involves the setting aside of good land, the use of irrigation water, and somewhat heavy expenses in purchasing trees, setting them out, and caring for them until they begin to bear.

Assuming that the climate and soil of the district selected are adapted to the kind of trees to be grown, the next most important things to consider are good drainage and freedom from early and late frosts. Low-lying lands under a new irrigation system should be regarded with suspicion, even if the subsoil is quite dry at the time of planting. The results of a few years of heavy and careless irrigation on the higher lands adjacent may render the lowlands unfit for orchards. On the other hand, the higher lands are not always well drained naturally. A bank of clay extending across a slope may intercept percolating water and raise it near the surface. Favored locations for orchards in the mountain States often are found in the narrow river valleys at the mouths of canyons. The coarse soil of these deltas, the steep slopes, and the wind which daily blow first out of the canyons and then back into them, afford excellent conditions for the production of highly-flavored fruits at the minimum risk of being injured by frost.

Proper exposure is another important factor. In the warmer regions of the West and Southwest a northern exposure sometimes is best, but as a rule the orchards of the West require warmth and sunshine, and usually a southerly exposure is most desirable. Natural barriers frequently intercept the sweep of cold, destructive winds, and when these are lacking, windbreaks may be planted to serve the same purpose.

The elevation of the locality likewise should be considered. As a rule, the higher the elevation the colder the climate and the shorter the growing season. The principal reason why peaches can be grown as successfully at Penticton, British Columbia, as at Brigham, Utah, is that Penticton is less than 1,300 feet above sea level, and Brigham is more than 4,300 feet above. It is true also that the low-lying lands of any locality are the most subject to frost. Depressions or sheltered coves should not be selected for orchards if the cold air has a tendency to collect in them, a free circulation of air being necessary to drive away frost.

A severe frost that did great damage to the citrus orchards of southern California in the month of January, 1913, demonstrated that the most desirable locations as regards freedom from injurious frosts are to be found on the upper slopes of the valleys and comparatively near bluffs adjacent to depressions into which the cold air may settle.

Experience has shown that orchard trees of nearly all kinds can be grown successfully on soils that differ widely in their mechanical and chemical composition, and it has also shown that certain types of soils are best adapted to particular kinds of trees. Thus the best peach, almond, apricot, and olive orchards of the West are found on the lighter or sandier loams; the best apple, cherry, and pear orchards on heavier loams; whereas walnut, prune, and orange orchards do best on medium grades of soil. The requirements of all, however, are a deep, rich, and well-drained soil.

TYPICAL WATER SUPPLIES FOR ORCHARDS.

Formerly most western orchards were supplied with water through earthen ditches. These leaky, unsightly channels, by reason of their cheapness, would have been retained very generally had it not been for the increasing value and scarcity of water. The value of water for irrigation purposes has increased very materially in recent years. In many localities there is likewise great scarcity at certain times. These rapidly changing conditions have induced many water companies to prevent some of their heavy losses in conveying water by substituting pipes for open ditches in earth, or else by lining the ditches to make them water-tight.

The high value and scarcity of the water in natural streams likewise have induced orchardists to put in pumping plants to raise water from underground sources. It was estimated that 24,600 of these plants were in operation in 1914 in California alone. In other parts of the West reservoirs are being built to supplement the late summer flow of streams which fail to provide enough water.

The few typical examples which follow may not only give the reader an idea of how orchards are supplied with water, but indicate also the customary division into tracts to serve this and other purposes.

Lewiston Basin is where Clearwater River flows into the Snake River in western Idaho, and varies from 700 to 1,900 feet above sea level. Some years ago water was brought from neighboring creeks and stored in a reservoir. The water required for orchard irrigation is conducted from this reservoir under pressure in two lines of redwood stave pipes over the rolling hills which separate the reservoir from the orchard lands. On these lands contour lines were first established, and each quarter section was afterwards divided into 40-acre tracts by 60-foot streets. These were further subdivided into eight 5-acre tracts, with a 20-foot alley through the center. Figure 1, showing block 28 of the survey, indicates the general arrangement. The large conduits from the reservoir are connected to smaller lateral pipes laid in the alleys, and these in turn are tapped by 3-inch pipes, which furnish water to the 5-acre tracts.

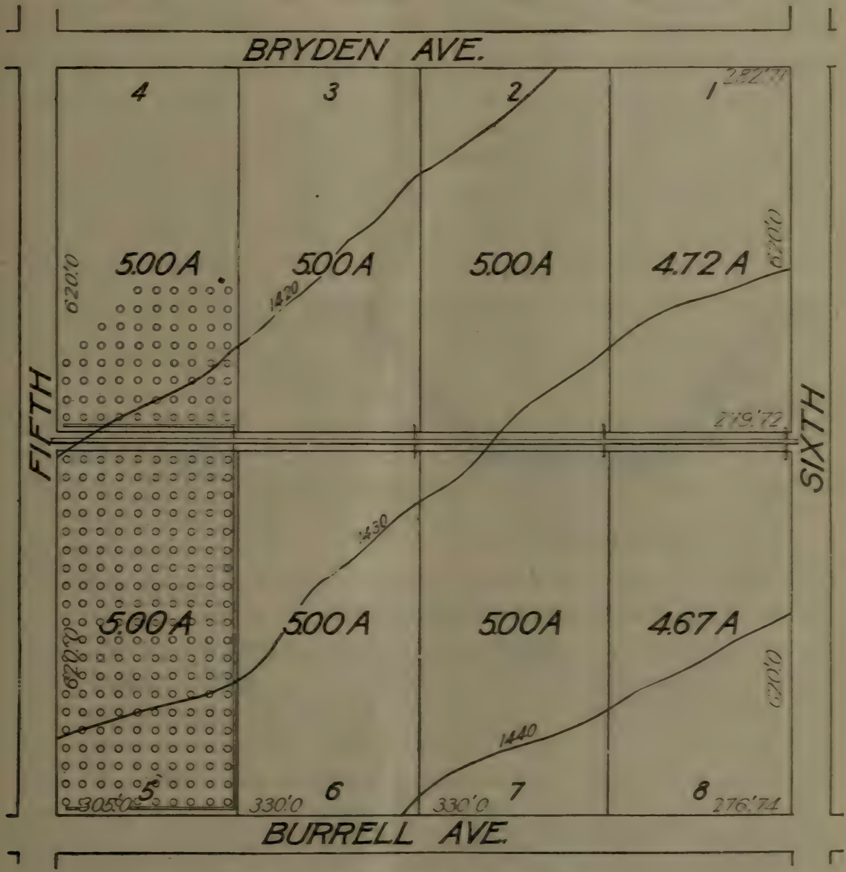

FIG. 1.—Orchard tracts at Lewiston, Idaho.

The chief water supply for the lemon groves in the vicinity of Corona, Cal., comes from Perris Basin, 40 miles distant. The company owns 3,600 acres of water-bearing lands in this basin and pumping plants have been installed at favorable points. These plants are operated by motors which formerly were supplied with current from a central generating station located at Ethenac, but in recent years the current has been purchased from the Southern Sierra Power Co., which transmits it across the Mojave Desert from Owens Valley.

Small lined channels convey the water from the pumps to the main conduit shown in cross section in figure 2. The concrete lining of this conduit is composed of one part cement to seven parts sand and gravel, having a thickness on the slopes of 2½ inches and on the bottom of 3 to 4 inches. The lining is made still more impervious by the addition of a plaster coat one-fourth of an inch thick, composed of one part of cement to two parts of sand. The cost was 5½ cents per square foot, or 55 cents per linear foot. The main conduit consists of about 30 miles of lined canal and 10 miles of piping 30 inches in diameter. As a rule the groves are laid out in 10 acre tracts, and piping of various kinds conveys the water from the main to the highest point of each tract, from which it is distributed between the rows in furrows.

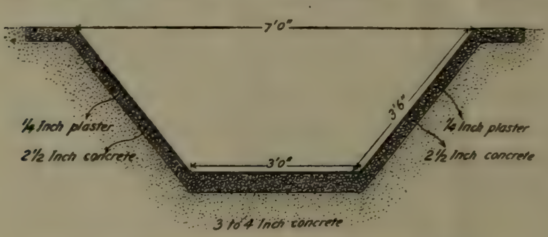

FIG. 2.—Concrete-lined canal of the Temescal Water Co.

A large part of the water used by the Riverside Water Co. is pumped from the gravelly bed of the Santa Ana River. Thence it is conveyed in a main canal to the orchard lands and distributed to the groves in cement and vitrified clay pipes. The owner of a tract, whether it be 10, 20, 30, or 40 acres in extent, receives his supply at the highest corner through a hydrant box. Each hydrant box not only allows the water to pass from the end of a lateral pipe to the head flume of the tract to be irrigated, but also measures the amount in miner's inches under a 4-inch pressure head as it passes through.

On the Gage Canal system in Riverside County, Cal., the water supply for the tiers of 40-acre tracts is taken from the canal in riveted steel pipes varying from 6 to 10 inches in diameter. These larger mains are connected with 4, 5, and 6 inch lateral pipes of the same material, which convey the water to the highest point of each 10-acre tract. This general arrangement is shown in figure 3.

The ditches conducting water from gravity canals to orchard tracts do not differ from the supply ditches for other crops which have been described in previous publications of this department.[1]

Various devices are used for the measurement of water applied to orchards. Where the water supply is conducted in open channels some form of the weir is the most common. The simplest form of this device consists of a wall or bulkhead built across the channel, with an opening, called a weir notch, cut in the top. This weir notch may be rectangular, trapezoidal, or triangular in form, and in all three the water is measured as it pours through the notch. The triangular notch is the best suited for small discharges, running from 1 to 50 or more miner's inches. For larger quantities the rectangular weir is to be preferred. Full instructions pertaining to the proper manner of building and setting weirs, together with tables of weir discharges, may be found in Farmer's Bulletin 813.

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[1] U. S. Dept. Agr., Farmers' Buls. 263 and 373.

When water is conveyed to orchards in pipes under pressure, the accurate measurement of the flow is more difficult and costly. In recent years a number of meters have been devised for this purpose, and of these mention may be made of the Venturi irrigation meter, the Binckley meter, the Grant-Mitchell, the Hill meter, and the Hanna meter. Several kinds of irrigation hydrants also have been devised, one of which is shown in figure 4 and another in figure 5.[1]

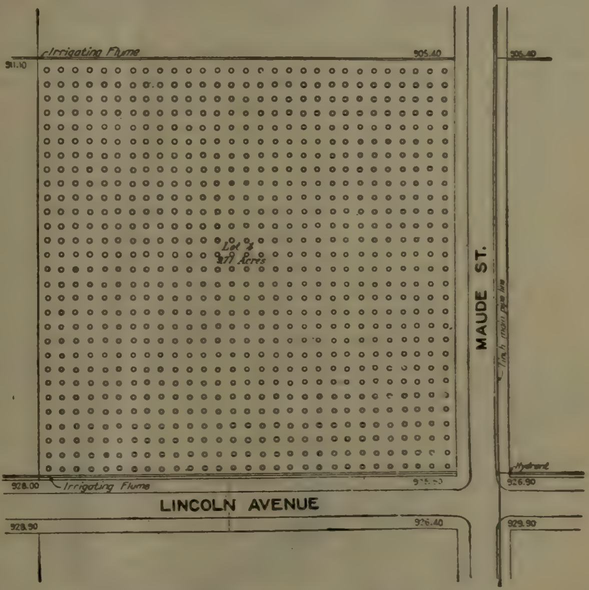

FIG. 3.—Orchard tract under Gage Canal, Riverside, Cal.

CLEARING AND GRADING LAND FOR FRUIT.

As a rule deciduous fruit trees are planted on land previously cultivated and cropped, but citrus fruit trees generally are planted on virgin soil. One of the best preparatory crops for deciduous orchards is alfalfa. This vigorous plant breaks up the soil and subsoil by its roots, collects and stores valuable plant foods, and when it is turned under at the end of the second or third year leaves the soil in much better condition for the retention of moisture and the growth of young trees.

In the Bitter Root Valley, Montana, new land is first plowed 8 to 12 inches deep, then carefully graded and smoothed and seeded to red clover for one or two seasons. On the west side of this valley pine trees and pine stumps are encountered. These can be removed best by burning. A hole 1½ inches in diameter is bored through the base of the stump or tree in a slanting direction. It is near the surface of the ground on the windward side and about 18 inches above the surface on the leeward side. A fire is then built in the hole, using small twigs to start it. As the fire burns the opening is increased and larger limbs are inserted. In two or three days the stump will have burned out, the fire burning down into the roots to a depth of 12 to 14 inches. The cost of such clearing varies with the character of the land and the density of the growth and with local prices of labor.

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[1] For description of these hydrants see Bulletin 247 of the University of California.

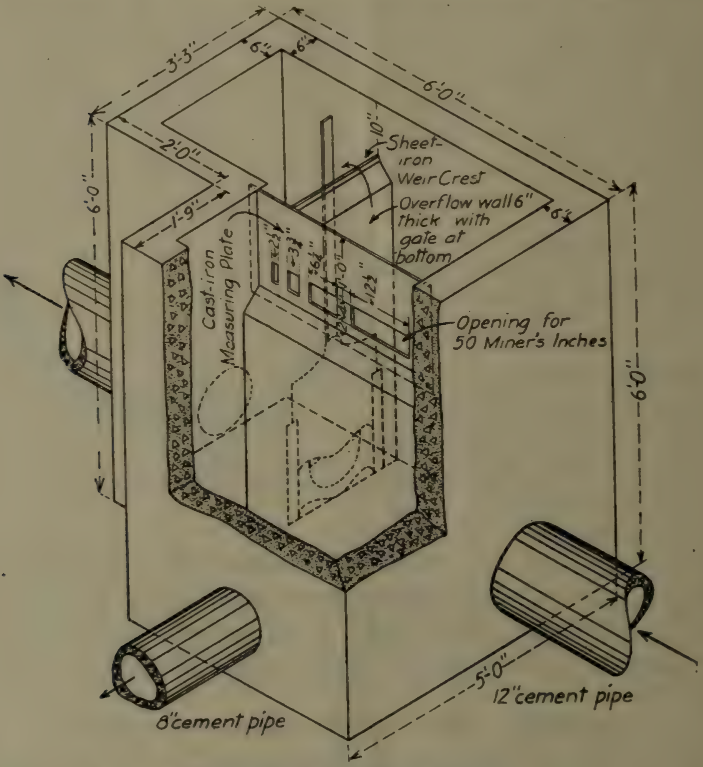

FIG. 4.—The Azusa irrigation hydrant.

Large areas of wooded lands in both the Hood River and Rogue River Valleys of Oregon have been cleared in order to plant apple trees. One of the methods employed in the Hood River district to rid the land of its growth of fir, pine, scrub oak, and laurel is similar to that just described. Another method consists in splitting open the stumps with giant powder and then pulling out the roots with a stump puller. Stump pullers of various kinds are used in California for a like purpose. The most powerful of these consists of a portable engine, windlass, and cable similar to an ordinary hoisting plant. A heavy chain is fastened to the tree at the proper height above the ground. The pulling cable is hooked to this chain and when the power is applied the tree is pulled out by the roots.

In New Mexico and Texas the mesquite is grubbed out usually by Mexicans, but in California, where labor costs more, such shrubs as mesquite, manzanita, and chaparral can be removed more cheaply by a pair of stout horses and a logging chain.

In many of the later plantings of citrus orchards in southern California large quantities of bowlders and cobble are hauled from the land and piled in walls around the edges of the 10-acre tracts. The cost of removing the rocks sometimes reaches $100 per acre. Such lands are among the most desirable for citrus fruits because they are located near the foothills and at elevations where there is less frost than in the lower parts of the valley.

Devices for the removal of ordinary desert plants, such as sagebrush and grease wood, have been described in another bulletin.[1]

An effort should be made to establish a fairly uniform grade from top to bottom of each tract. This is done by cutting off the high points and depositing this earth in the depressions. The length of the furrows should not exceed one-eighth of a mile and in sandy soil they should be shorter. As a rule, it is not difficult to grade the surface of an orchard so that small streams of water will flow readily in furrows from top to bottom.

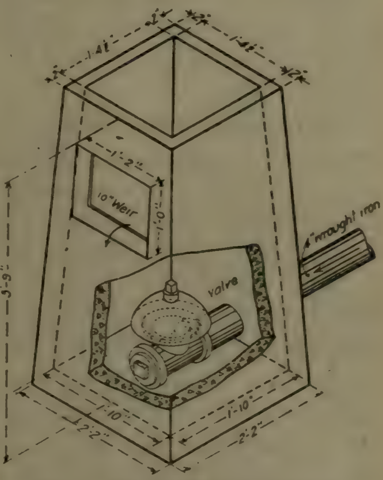

FIG. 5.—The Gage irrigation hydrant.

LOCATING THE TREE ROWS.

Before setting out orchards which are to be irrigated, the elevations of all parts of the surface of the ground should be ascertained. This is usually done by making a contour survey by which each tract is divided up by level lines into a number of curved strips or belts. Such contours are shown in figure 1, the vertical distance between them in this particular case being 1 foot. With these as a guide the direction of the tree rows can be determined readily. Where the trees are watered in basins or checks, flat slopes are not so objectionable, but in furrow irrigation a slope of at least 2 inches to 100 feet is necessary to insure an even distribution of water. When streams are to be run in the furrows the slope of the furrows may be increased to 8, 10, and even to 12 inches to 100 feet. On slopes varying from 10 to 40 feet to the mile, the tree rows therefore may be located at the proper distance apart down the steepest slope. Under such conditions the trees usually are planted in squares. On steep slopes the trees usually are planted on graded curved lines so as to prevent furrow erosion and to facilitate the distribution of water along flatter slopes. The new plantings of citrus orchards at Riverside, Cal., on steep hill sides, are laid off on graded curved lines in which the fall ranges from 0.2 per 25 feet to 1 in 100 feet. (See illustration on title-page.) The Limoneria Company, of Santa Paula, Cal., has adopted a grade of 1.25 per cent for its lemon orchards, but the orange and lemon trees of the Mills orchards on the west side of the Sacramento Valley have a grade of 2 to 3 inches between trees, which are spaced 24 feet apart.

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[1] U. S. Dept. Agr., Farmers' Bul. 865.

The location of the trees can be fixed best by the use of a surveyor's transit and steel tape. When these are not available, a woven-wire wire cable about three-sixteenths of an inch in diameter will answer the purpose. If apple trees are to be set out and it is desired to have them 32 feet apart, tags are inserted between the strands of the cable to mark this exact distance. A base line at the proper distance from the fence or one margin of the field is then laid down and long sighting stakes driven at each tag. The corner is then turned and a similar line is laid out. This process is continued until the location of the trees around each of the four sides of the tract has been fixed. The corners can best be turned with a 100-foot tape or link chain. First measure from the end of the base line a distance of 30 feet. Hold the one-hundred end of the chain at this point, and the 10-foot link at the corner; take the tape or chain at the 50-foot mark or link and pull both lines taut. A stake driven at this vertex will establish a point on a line at right angles to the first. When stakes have been set on all four sides, the intermediate locations for the trees can be ascertained readily by sighting between corresponding marginal stakes.

Where the slope is steep and difficulties are likely to be encountered in distributing water, the equilateral, hexagonal, or septuple method of planting, as it is variously termed, should be adopted. The manner of marking the ground for this method is indicated in figure 6. It will be observed that in this method the ground is divided up into equilateral triangles, with a tree at each vertex. The trees likewise form hexagons, and including the center tree of each hexagon they form groups of sevens. Hence the names equilateral, hexagonal, and septuple.

The chief advantage of this mode of planting in irrigated districts is that it provides three and often four different directions in which furrows may be run. Having the choice of so many, it is not difficult to select the one which is best for any particular tract. The ground likewise can be cultivated in more ways and about one-seventh more trees can be planted to a given area than is possible in the square method.

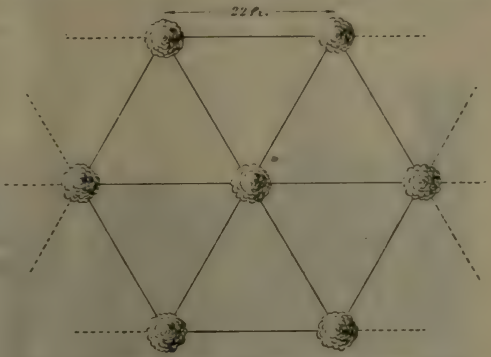

Fig. 6.—Hexagonal method of setting out orchard trees.

In the past the trees of irrigated orchards have been planted too close. This is made clear to even the casual observer who visits the old orange groves of Riverside, Cal., the deciduous orchards of the Santa Clara Valley, California, or the apple orchards of the Hood River district in Oregon. Under irrigation systems peach trees should be spaced 20 to 22 feet, olive, pear, apricot, and cherry trees from 22 to 28 and 30 feet, orange trees 22 to 24 feet, apple trees 30 to 36 feet, and walnut trees from 48 to 56 feet apart.

On the Pacific coast the tendency toward wide spacing has induced many growers to insert peach fillers between slower maturing trees, such as the apple and walnut. A common practice in this direction is shown in figure 8, which represents the arrangement of trees in an orchard in Douglas County, Wash. Here the trees are set in squares 18 feet each way, but in every other row peach trees alternate with the standard apple trees. In the remaining rows Winesap apple trees are used for fillers. As the apple trees grow and begin to crowd the fillers, the peach trees are removed. If more space is required the Winesaps can be taken out, leaving the apple trees in squares 36 feet apart both ways.

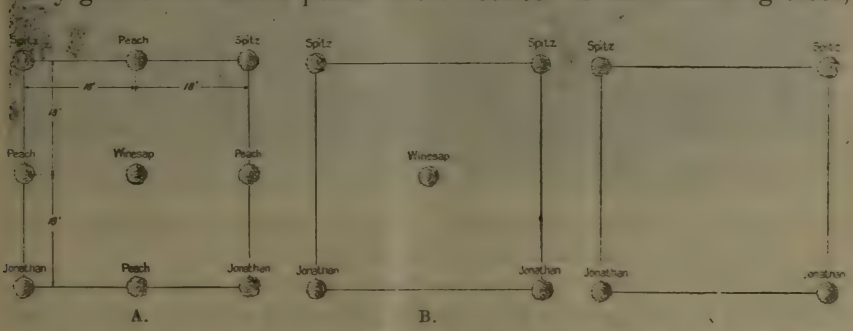

Fig. 7.—Plan of planting apple trees with peach trees a fillers; A, Trees as planted at first; B, peach trees removed; C, Winesap removed.

METHODS OF IRRIGATING ORCHARDS.

FURROW IRRIGATION.

The most common method of irrigating orchards is by means of furrows. These vary in depth, length, and distance apart to conform to local requirements arising from the character of the soil and surface, the quantity of water used, and other conditions. The manner of distributing water to the upper end of each furrow likewise varies in accordance with the efficiency of the irrigation system, the amount of money expended, the skill used in installation, and the value and average annual profits of the orchard.

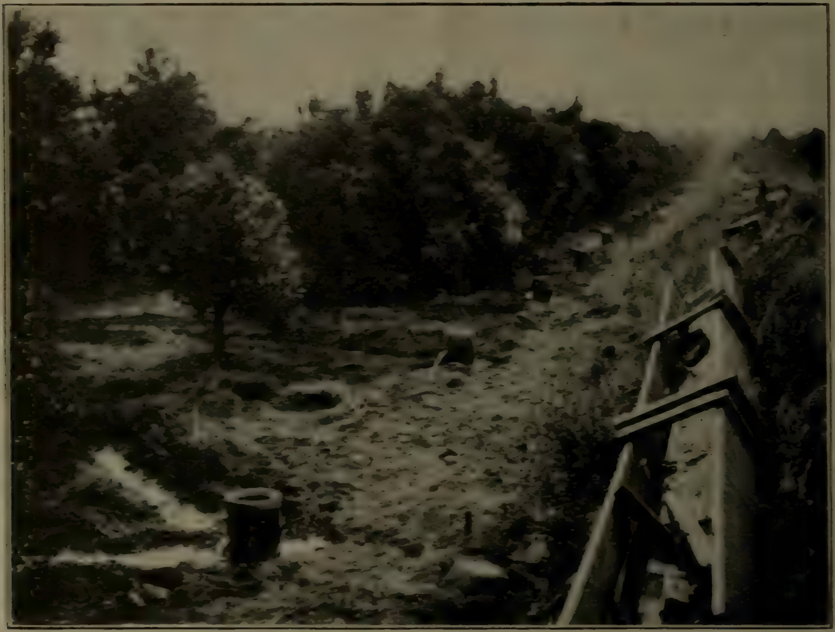

FIG. 8.—Discarded lumber head flume replaced by concrete pipe and stand system.

Expensive devices for distributing water into furrows are not warranted in orchards of little value and small annual returns. On the other hand, it may prove an economical investment to provide valuable orchards, yielding high annual returns, with the best known devices for successful irrigation. Such a device is unquestionably the concrete or other underground pipe fitted with suitable standpipes. At the other extreme is to be found the earthen ditch. Figure 8 shows a discarded lumber head flume replaced by a concrete pipe and stand system.

EARTHEN HEAD DITCHES.

Permanent ditches at the head of orchard tracts should be located by a surveyor. The proper grade depends chiefly on the soil. If the soil is loose and easily eroded, a slow velocity is best. On the other hand, the velocity must be sufficiently rapid to prevent the deposition of silt and the growth of water plants. In ordinary soils, a grade of 2½ inches to 100 feet for a ditch carrying 2 cubic feet per second is not far out of the way. The amount of water to be carried varies from ½ to 2 or more cubic feet per second. A ditch having a bottom width of 24 inches, a depth of 6 inches, and sloping sides, ought to carry 1½ cubic feet per second on a grade of half an inch to the rod or 3 inches to 100 feet. Such a ditch may be built by first plowing four furrows and then removing the loose earth with either shovels or a narrow scraper. The loose earth likewise may be thrown up on the sides and top by means of the homemade implement shown in figure 9. Canvas dams, metal tappoons, or other similar devices are inserted in the head ditch to raise the surface of the water opposite that part of the orchard where furrows have been made and which is about to be watered. The chief difficulty in this mode of furrow irrigation arises in withdrawing water from the ditch and in distributing it equally among a large number of furrows. A skilled irrigator may adjust the size and depth of the ditch bank openings so as to secure a somewhat uniform flow in the furrows, but constant attention is required in order to maintain it. If the water is permitted to flow for a short time unattended the distribution is likely to become unequal. Parts of the ditch bank become soft, and, as the water rushes through, the earth is washed away, permitting larger discharges and lowering the general level of the water in the ditch so that other openings may have no discharge.

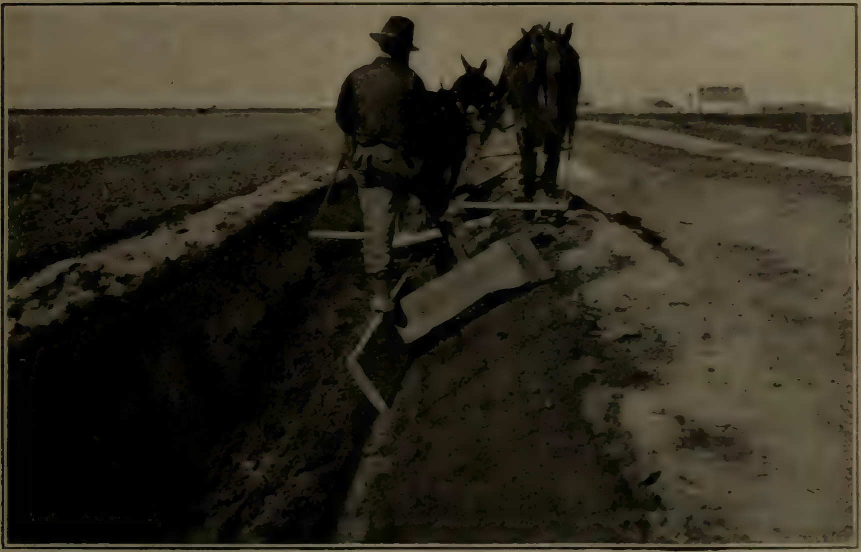

FIG. 9.—The use of the "A" scraper in building head ditches.

Some of the orchardists of San Diego County, Cal., insert in niches cut in the bank pieces of old grain sacks or tent cloth. The water flows over these without eroding the earth. Another device is to use a board pointed at the lower end and containing a narrow opening or slot through which the water passes to the furrow. Shingles are also used to regulate the flow in the furrows. The thin ends of these are stuck into the ground at the heads of furrows.

SHORT TUBES IN HEAD DITCHES.

Short tubes or spouts have been used in many of the head ditches of orchards to divert small quantities of water to furrows. These tubes usually are made of wood, but pipes made of clay, black iron, galvanized iron, and tin are used occasionally.

For nurseries and young trees especially, and also for mature trees, a cheap and serviceable tube may be made from pine lath, such as are used for plastering. The 4-foot lengths are cut into two equal parts and four of these pieces are nailed together to form a tube. One of these tubes when placed with its center 2 inches below the surface of the water in the head ditch discharges nearly three-quarters of a miner's inch of water, and if placed 4 inches below the surface will discharge more than 1 miner's inch. In southern Idaho the lumber mills manufacture a special lath for this purpose. It is ½ inch thick, 2 inches wide, and 36 inches long. If such tubes when thoroughly dry are dipped in hot asphalt they will last a much longer time. In some of the deciduous orchards of California a still larger wooden tube or box is used. Figure 10 represents one of these. It is made of four pieces of ¾ by 3¾ inch redwood boards of the desired length. The flow through this tube is regulated by a cheap gate, consisting of a piece of galvanized iron fastened by means of a leather washer and a wire nail.

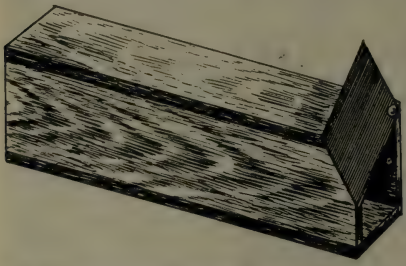

FIG. 10.—Wooden box placed in bank of head ditch.

The orchardist who lives near a manufacturing town or city can often purchase at a low figure pieces of worn-out and discarded piping varying from ¾ to 2 inches in diameter. Such pipes when cut into suitable lengths make a good substitute for wooden spouts. Tin tubes one-half inch in diameter and of the proper length have been used with good success. In compact soils, through which water passes very slowly, the furrows must be near together, and under such conditions small tin tubes are to be preferred.

In making use of tubes of various kinds to distribute water to furrows it is necessary to maintain a constant head in the supply ditch.

This is done by inserting checks at regular distances. These distances vary with the grade of the ditch, but 150 feet is not far from being an average spacing. In temporary ditches the canvas dam is perhaps the best check, but in permanent ditches it pays to use wood or concrete. An effective wooden check is shown in figure 11. In this the opening is controlled by a flashboard which may be adjusted so as to hold the water at any desired height and at the same time permit the surplus to flow over the top to feed the next lower set of furrows.

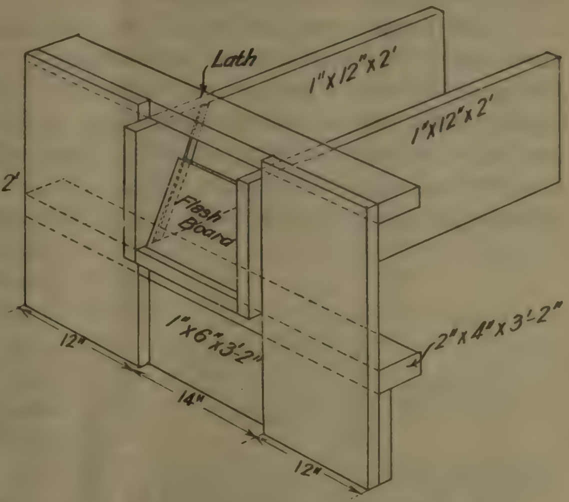

FIG. 11.—Wooden check in head ditch

HEAD FLUMES.

Formerly head flumes for orchards were built of wood, but the steady increase in the price of lumber and the decrease in the price of Portland cement have induced many fruit growers to use cement instead. When built of wood, the length of the sections varies from 12 to 20 feet, 16 feet being the most common. The bottom width runs from 6 to 12 inches, and the depth usually is 1 to 2 inches less. Red-wood lumber 1¼ inches thick is perhaps the best for the bottom and sides, and joists of 2 by 4 inch pine or fir are commonly used for yokes which are spaced 4 feet centers. Midway between the yokes auger holes are bored and the flow through these openings is controlled in the manner shown in figures 12 and 13. A 2-inch fall for each hundred feet may be regarded as a suitable grade for head flumes, but it

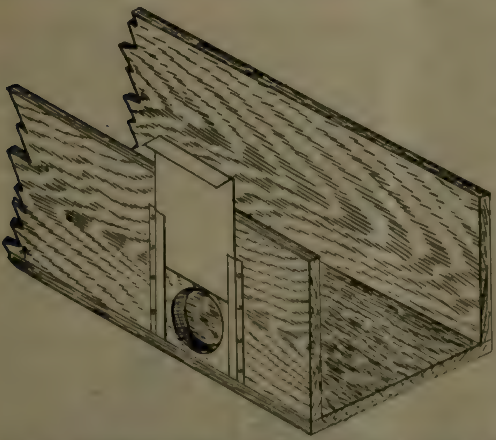

FIG. 12.—Section of wooden head flume, showing opening and gate.

often happens that the slope of the land is much greater than this, in which case low checks are placed in the bottom of the flume at each opening, as shown in figure 13.

A head flume composed of cement, sand, and gravel costs as a rule about twice as much as a wooden flume of the same capacity, but the early decay of wood, especially if it comes in contact with earth, makes the cement flume cheaper in the end. By means of a specially designed machine, which is patented, cement mortar composed of one part cement to about six parts of coarse sand is fed into a hopper and forced by lever pressure into a set of guide plates of the form of the flume. Such flumes are made in place in one continuous line across the upper margin of the orchard tract. After the flume is built and before the mortar has become hard, small tubes from $\frac{3}{4}$ to $1\frac{1}{2}$ inches in diameter, the size depending somewhat on the size of the flume, are inserted in the side next the orchard. The flow through these tubes is regulated by zinc slides shown in figure 13. Flumes of this kind are made in five sizes, the smallest being 6 inches on the bottom in the clear and the largest 14 inches.

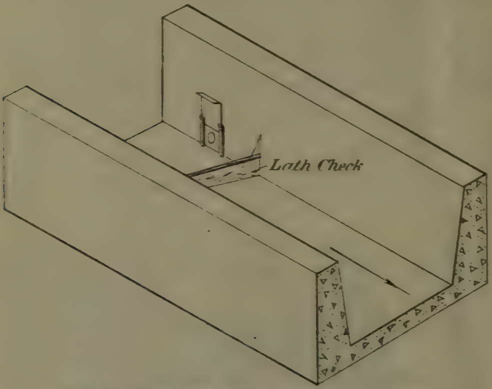

FIG. 13.—The use of low check in head flume.

At a slightly greater cost a stronger flume can be built by the use of molds. The increased strength is derived from a change in the mixture. In the machine-made flume the mixture of 1 part cement to 5 or 6 parts of sand is lacking in strength, because there is not enough cement to fill all the open spaces in the sand. In using molds medium-sized gravel can be added to the sand and the mixture resembles that of the common rich concrete.

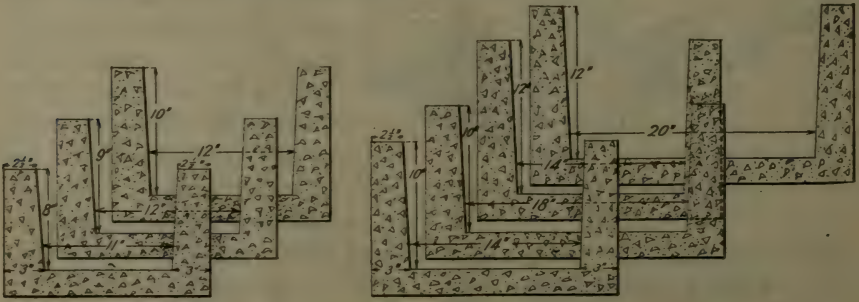

FIG. 14.—Common sizes of concrete head flumes.

Such flumes can be built of almost any size from a bottom width of 10 inches to one of 40 inches and from a depth of 8 inches to one of 24 inches, but when the section is increased beyond about 240 square inches it pays better to slope the sides outward and adopt the form of the cement-lined ditch. The quantity of concrete required per linear foot of flume depends on its size and the thickness of its sides and bottom. The dimensions given in figure 14 are for light rather than for heavy flumes and are designed for localities where there is little frost.

For large head flumes and laterals, many fruit growers first carefully prepare an earthen ditch which has carried water for at least one season and afterwards line the inner surface with cement concrete. Figure 15 shows a section of such a ditch.

Some years ago 3,200 linear feet of head ditches were lined for 26½ cents per foot; they were 14 inches on the bottom with 18-inch sides and a 2-inch lining. The cement cost $2.85 per barrel, gravel 75 cents per yard, and labor $1.75 to $2.50 per day. Present prices of both materials and labor are higher, but the prices quoted will give an idea of cost.

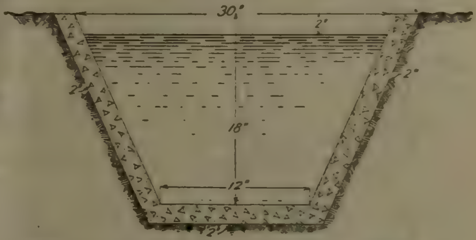

FIG. 15.—Earthen head ditch lined with concrete.

PIPES AND STANDPIPES.

Head flumes, being placed on the surface of the ground, interfere with the free passage of teams in cultivating, irrigating, and harvesting the crop. Dead leaves from shade and fruit trees also clog the small openings in the flumes. These and other objections to flumes have induced many fruit growers of southern California to convey the water in underground pipes and distribute it through standpipes placed at the heads of the rows of trees. Both cement and clay pipes are used for this purpose.

The cement pipes are usually molded in 2-foot lengths, with beveled lap joints, and consist of a 1 to 3 or 1 to 4 mixture of cement and fine gravel and sand. The most common sizes are 8, 10, and 12 inches in diameter, having a thickness of shell in the 12-inch pipe of 1½ inches which is reduced to a trifle more than 1 inch in the 8-inch pipe. Piping of this kind, when well made and carefully laid, will withstand a head of 10 to 16 feet.

The clay pipe is similar to that used for sewers in cities but usually has some minor defect which causes its rejection for that purpose. It is graded accordingly into Nos. 1, 2, and 3 pipe. Piping of No. 1 grade ordinarily can be expected safely to withstand heads up to 30 feet.

A line of pipe is laid about 2 feet below the surface from the feed main and measuring box across the top of the orchard, and as each row of trees is passed a standpipe is inserted. The general plan is shown in figure 16. Various devices are employed to convey the water from the pipe to the surface of the ground at the head of each tree row and divide it up evenly among 4 to 6 furrows. One of the most common consists of a series of standpipes, the top of each set rising to the same elevation. At each change of elevation special standpipes are used, and in these are inserted gates provided with overflows. (Figs. 17 and 18.) The manner of distributing the water from a standpipe to the furrows of any one row is shown in figure 19.

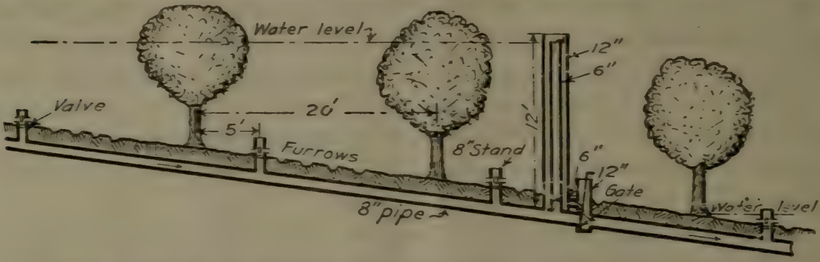

FIG. 16.—The use of underground pipe in furrow irrigation, showing risers and stand.

Occasionally throughout the Rocky Mountain States a high-pressure pipe is substituted for cement and clay. This is tapped at the head and in line with each row of trees, and a small galvanized-iron pipe is inserted. These standpipes are capped by an ordinary valve which regulates the flow to each row of trees. This method is shown in operation in figure 20, where a young orchard is being irrigated from $\frac{3}{4}$-inch galvanized-iron standpipes connected to a 3-inch wooden pipe. It will be noted, however, that the water as it flows from the standpipes is not controlled properly, and proper devices should be introduced to check the velocity, distribute the water more equally to the several furrows, and prevent the erosion of the soil.

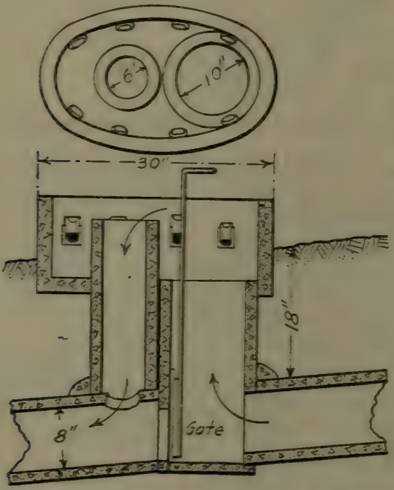

FIG. 17.—Standpipe used in distributing water to furrows.

MAKING FURROWS.

The length of the furrow often is governed by the size of the orchard. The rows of citrus trees seldom exceed 40 rods in length, but the apple orchards of the Northwest are larger as a rule. Even in large tracts it is doubtful if it ever pays to run water in furrows more than about 600 feet. Where the soil is open and water sinks readily through it, short furrows should be used, otherwise much

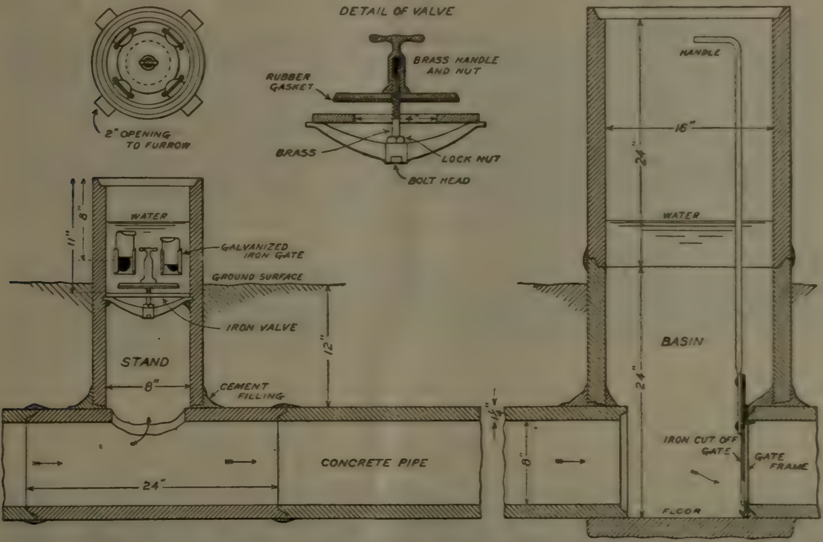

FIG. 18.—Design for concrete pipe and stand system for orchard irrigation.

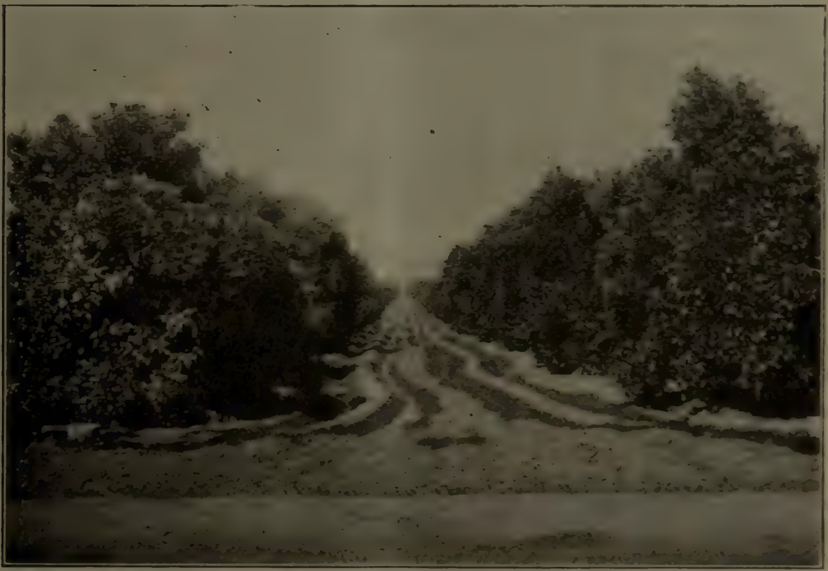

FIG. 19.—Method of distributing water from standpipe to furrows.

water is lost in deep percolation on the upper part of the tract. Prof. H. Culbertson, of San Diego County, Cal., after a careful investigation of this subject has reached the conclusion that on sandy or gravelly soil having a steep slope the proper length of furrows is 200 feet, whereas on heavier soils and flatter slopes the length may be increased to 600 feet.

The grade of furrows varies quite widely. In flat valleys it often is not possible to obtain a fall greater than 1 inch to 100 feet, whereas on steep slopes the fall may reach 20 inches per 100 feet. On ordinary soils a grade of 3 to 4 inches is to be preferred, and where the fall exceeds 8 to 10 inches to 100 feet the trees should be set out in such a way as to decrease the slope of the furrows.

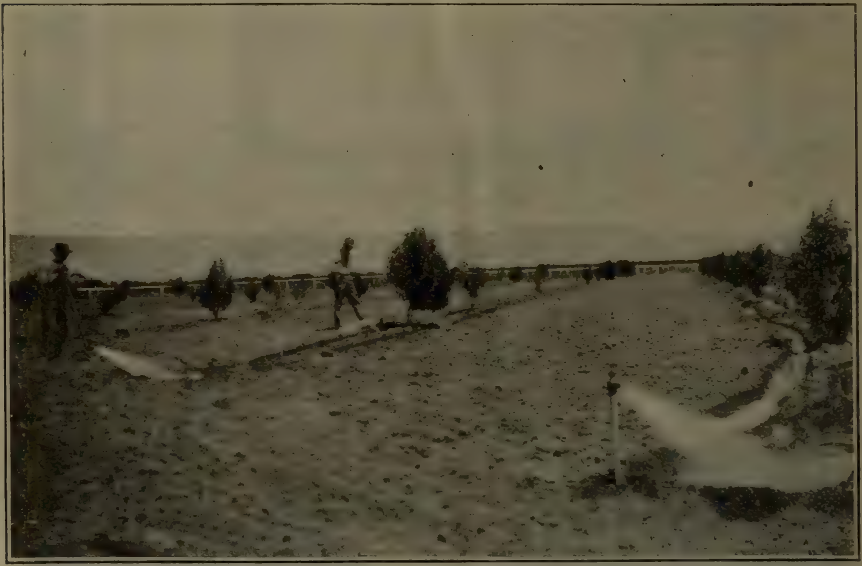

FIG. 20.—Method of irrigating from iron standpipes connected with pressure pipes.

The number of furrows in orchards depends on the age of the trees, the space between the rows, the depth of furrow, and the character of the soil. Nursery stock is irrigated by one or two furrows and young trees by two to four (fig. 21). A common spacing for shallow furrows is 2½ feet, but deeper furrows are made 3 to 4 feet apart (fig. 22). The general trend of orchard practice is toward deep rather than shallow furrows, a depth of 8 inches being used in many instances.

In spacing furrows chief consideration should be given to the lateral movement of moisture in the soil on each side of the furrows, so as to insure a fairly uniform distribution of moisture.

The furrowing implement most commonly used by the citrus orchardists of southern California consists of a sulky frame to which are

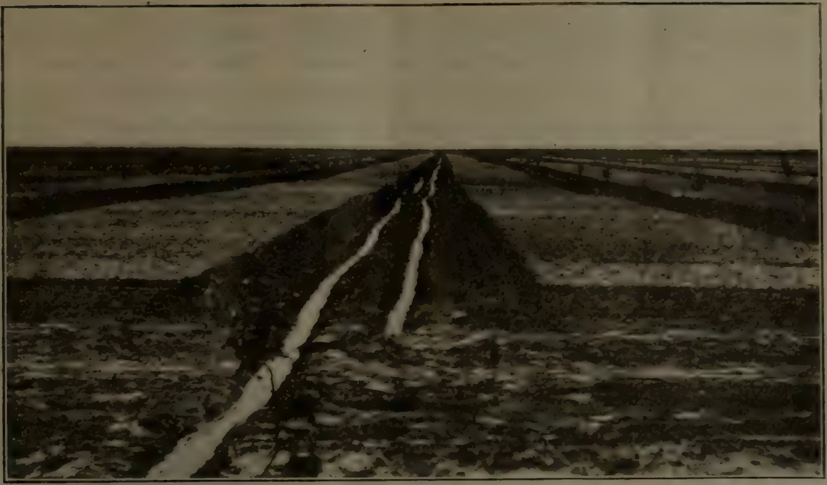

FIG. 21.—Irrigating young orchards in southern Idaho.

attached two or three double moldboard plows. Those who prefer a small number of deep furrows use a 12 to 14 inch corn lister. In figure 23 is shown a furrower made by attaching an arm to a cultivator and then fastening two shovels to the arm. In the view the space between the furrows is 4½ feet and the depth is regulated by the lever arm of the cultivator.

APPLYING WATER TO FURROWS.

In the Payette Valley, Idaho, 200 or more miner's inches are turned into the head ditch and divided up by means of wooden spouts into

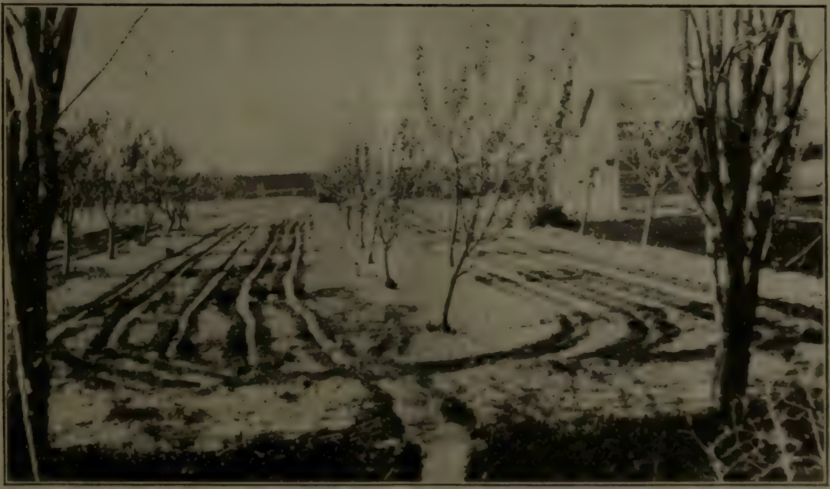

FIG. 22.—Usual method of irrigating orchards in Idaho.

a like number of furrows. On steep ground much smaller streams are used. The length of the furrow varies from 300 feet on steep slopes to 600 feet and more on flat slopes. The time required to moisten the soil depends on the length of the furrow and the nature of the soil. In this locality it varies from 3 to 36 hours.

A 20-acre orchard tract under the Sunnyside Canal in the Yakima Valley, Wash., is watered four times in each season with 14 miner's inches (0.35 cubic foot per second). Three furrows are made between the rows, which are 40 rods long. The total supply is applied to one-half the orchard (10 acres) and kept on 48 hours.

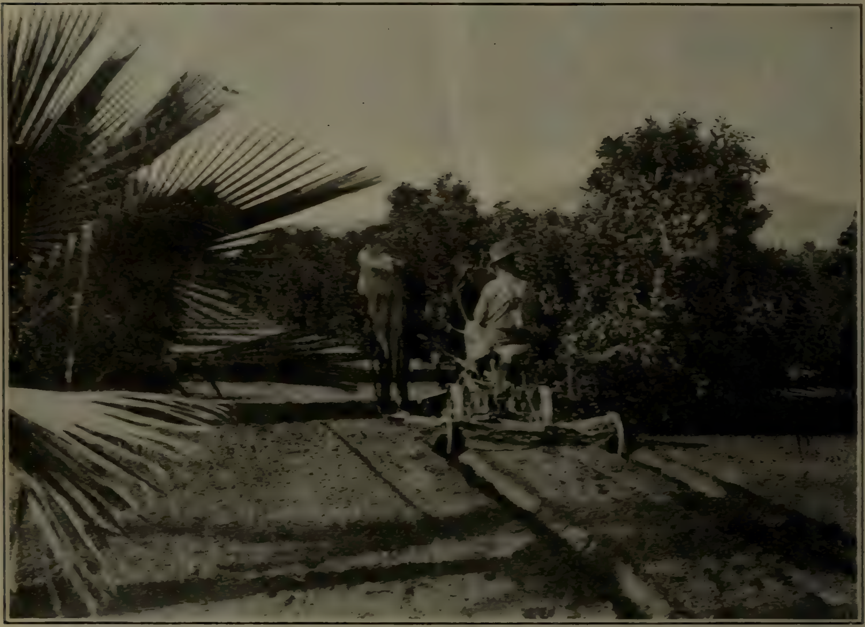

FIG. 23.—Making furrows in orchard.

On the clayey loams of the apple orchards on the east bench of the Bitter Root River, Mont., Prof. R. W. Fisher, formerly horticulturist of the Agricultural College of Montana, has found, as a result of experimenting, that it requires from 12 to 18 hours to moisten the soil in furrow irrigation 4 feet deep and 3 feet sideways.

In 1908 an orchardist of Hood River, Oreg., irrigated 3 acres of apple trees in furrows 350 feet long, spaced 3 feet apart. About a miner's inch of water was turned into each alternate furrow from a wooden head flume (fig. 12) and kept on for about 48 hours. After the soil had become sufficiently dry it was cultivated, and in 8 or 10 days thereafter water was turned into the alternate rows, which were left dry during the first irrigation.

For the most part, the furrows are made parallel to the rows of trees. An arrangement of this kind is satisfactory in young orchards, but as the trees reach maturity their branches occupy more of the open space between the rows and prevent the making of furrows near the trees. This is shown in figure 24, where a space of 6 to 12 feet square, according to the size of the trees, is not furrowed. This space usually becomes so dry that it is worthless as a feeding ground for roots. In order to moisten these dry spots, a larger stream often is carried in the two furrows next to each row of trees and the surplus is led across in short furrows in the manner shown in figure 25. Instead of continuing straight and cross furrows, as is done in figure 25, use is frequently made of diagonal furrows to moisten the dry space between the trees. This last method is best adapted to grades of 5 inches to 100 feet or more.

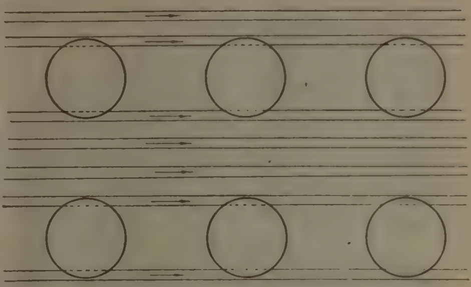

FIG 24.—Furrow irrigation, showing dry spaces.

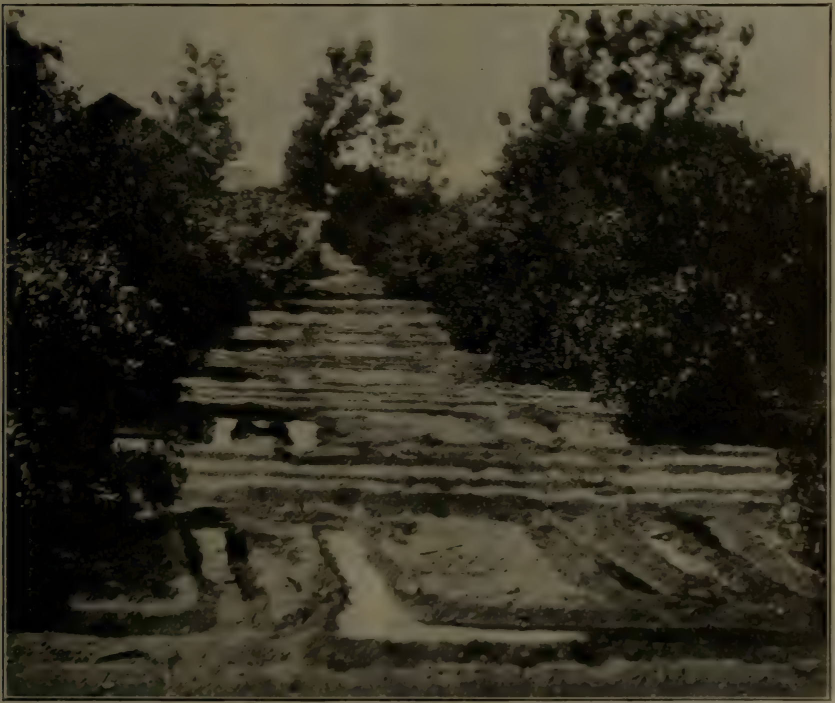

FIG. 25.—Cross-furrowing the dry spaces.

A method and the cost of one irrigation is described as follows:

The implement used to make furrows consists of three shovels attached to a beam, which is mounted on a pair of low wheels.

The driver sits on a riding seat and by operating a lever can regulate the depth of the furrows. A man and two horses will furrow out 10 acres in a day. For a distance of 150 feet from the top of the orchard the furrows are straight. They are then zigzagged to within 60 or 70 feet of the bottom, where the last three rows of trees are irrigated by basins which catch the surplus. In the case described the depth of furrow was 6 inches, length 800 feet, and distance apart 3 feet. A head of 50 miner's inches (1 cubic foot per second) was used on 10 acres. The streams when first turned into the furrows averaged about 2 miner's inches, but as the water approached the lower end they were reduced to 1 miner's inch or less, and this flow was run in each furrow for 12 to 24 hours.

The items of cost for 10 acres were as given below:

Making furrows and basins	$6.50
Irrigating	3.00
Fifty inches of water, 24 hours, at 40 cents an hour	9.60
Rent of water stock	12.00
Total	31.10

The present high prices of labor would increase this cost somewhat.

THE BASIN METHOD.

Orchards sometimes are irrigated by first forming ridges midway between the rows in two directions at right angles to each other. This divides up the tract into a large number of squares with a tree in the center of each, as may be observed in figures 26 and 27. In rarer cases a basin or check incloses four or more trees.

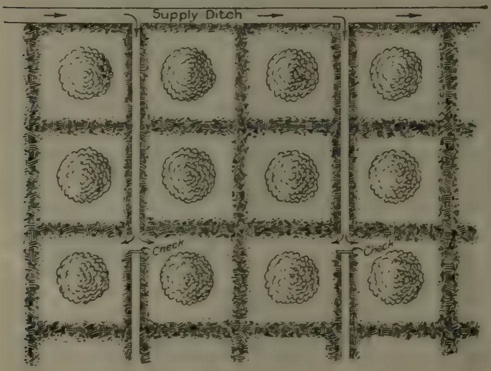

FIG. 26.—Basin method of irrigation.

When the ground is hard or covered with weeds, a disk plow is run between the rows and then the loosened earth is formed into a ridge by a ridger. If the soil is light, sandy, and free from weeds, the disking is not necessary. Ridgers are made in various ways of both wood and steel or some combination of both. A common kind is shown in figure 28. It consists of two deep runners 14 to 18 inches high, 2 inches thick, and 6 to 8 feet long. These runners are shod with steel which extends part way up the inner side. They are 4 to 5 feet apart at the front end and tapered to 16 to 24 inches at the rear. The runners are held in position by cross pieces on top, a floor, and straps of steel in the manner shown. Figure 29 shows a steel ridger which is used for the same purpose and in the same manner as the steel-shod wooden ridger shown in figure 28.

The height of the ridges varies with the depth of water applied, which is from 4 to 9 inches. The ridges should be several inches above the surface of the water when a basin is flooded.

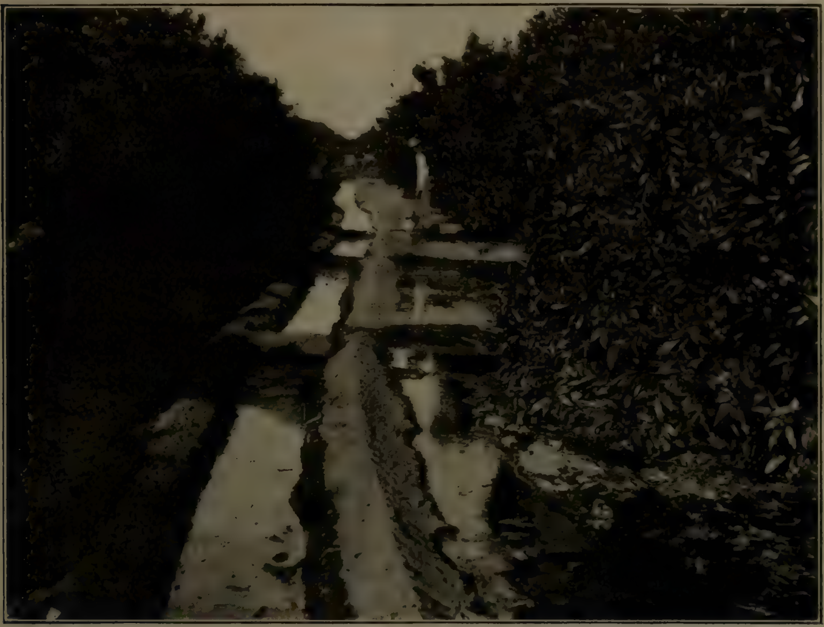

FIG. 27.—View of orchard being irrigated by basin method.

Several methods of flooding basins are practiced. In one a ditch is run from the supply ditch at the head through each alternate row space and the basins on each side are flooded in pairs, beginning with the lowest. This plan is shown in outline in figure 27. In the other method water is allowed to flow through openings into each basin of a tier in a zigzag course from the top to the bottom of the orchard. In this plan the upper basins receive the most water. Under gravity canals, where water is abundant, the water is turned into the upper basin until it is full, when it overflows into the next, and so on down the tier. The irrigator then begins at the lower end and repairs the breaks, leaving each basin full of water.

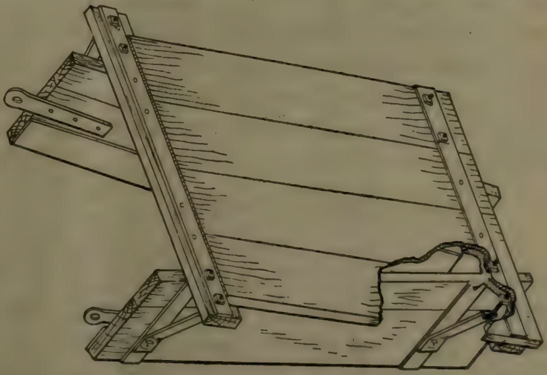

FIG. 28.—Adjustable ridger.

Interest in basin irrigation has been renewed of late in California owing to the fact that by this method of preparing land and applying water it has been found possible to mulch each basin throughout the dry season with cured alfalfa, bean straw, or other leguminous product. The soluble ingredients of such a mulch are carried by the irrigation water into the soil and in this way both food and moisture are furnished to the tree. This is a revival of a very old practice. Ibn el Awam, or Abu Zacaria, as he is called otherwise, who wrote in the twelfth century, speaks many times of mulches of straw, preferably bean stalks, in his book on agriculture.[1] The same author in another part of his work gives the following advice:

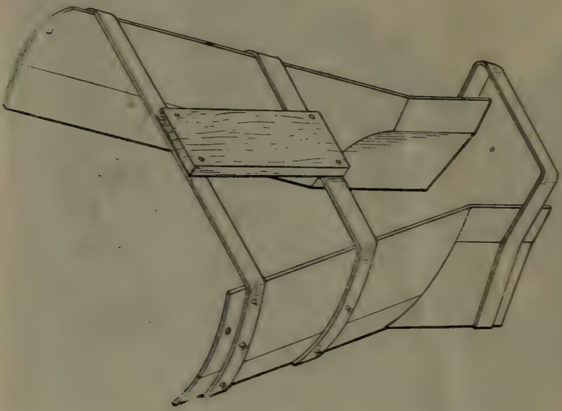

FIG. 29.—Steel ridger.

> You next take bean stalks with the beans stripped off, coming from the crop of the previous year and quite large. They are thrashed so as to reduce them to the state of very fine straw. This straw is spread in abundance on the soil after plowing and you irrigate on top of it.

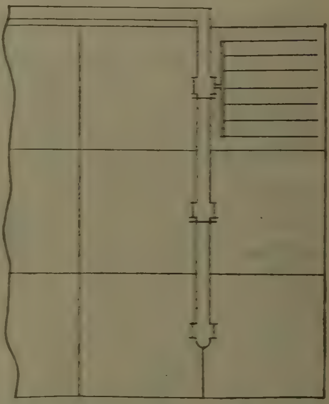

FIG. 30.—Combination of check and furrow methods.

Guillochan[2] says that it is excellent orchard practice after rotted manure has been spaded in early in the spring and the basins (cuvettes) have been formed for receiving irrigation to fill the latter with straw manure or, if this is not to be had, with dry grass.

THE CHECK METHOD.

Where the check method is practiced it frequently happens that land on which alfalfa has been grown is planted to fruit trees. In plowing down the alfalfa and setting out the trees, the levees undergo little change and the checks can be flooded if it is considered best. A better plan is to furrow the floor of each check as shown in figure 30. The water is admitted through the check box which was used for the alfalfa and conducted into a short head ditch, from which it is distributed to the furrows. The chief objection to this method is that the checks are too small for orchard tracts in furrow irrigation.

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[1] Kitab al-Felahah: translated into Spanish by José Banqueri. Madrid, 1802, and into French by J. H. Clement-Mullet. Paris, 1864–1866.

[2] Traité paratique d'horticulture pour le Nord d'Afrique, Paris, 1907, p. 185.

TIME TO IRRIGATE ORCHARDS.

The best orchardists believe that frequent examination of the stem, branches, foliage, and fruit is not enough. The roots and soil should be examined also. The advice of such men to the inexperienced is: Find out where the bulk of the feeding roots is located, ascertain the nature of the soil around them, and make frequent tests as to the moisture which it contains. In a citrus orchard of sandy loam samples are taken at depths of about 3 feet, and the moisture content determined by exposing the samples to a bright sun for the greater part of a day. It is considered that 6 per cent by weight of free water[1] is sufficient to keep the trees in a vigorous condition.

Doctor Loughridge, of the University of California, in his experiments at Riverside, Cal., in June, 1905,[2] found an average of 3.5 per cent in the upper 2 feet and an average of 6.16 per cent below this level in an orchard which had not been irrigated since October of the preceding year. It had received, however, a winter rainfall of about 16 inches. On examination it was found that the bulk of the roots lay between the first and fourth foot. These trees in June seemed to be merely holding their own. When irrigated July 7 they began to make new growth. A few days after the water was applied the percentage of free water in the upper 4 feet of soil rose to 9.64 per cent. The results of these tests seem to indicate that the percentage by weight of free moisture [1] should range between 5 and 10 per cent in orchard loams.

Many fruit growers do not turn on the irrigation stream until the trees begin to show visible signs of suffering, as a slight change in color or a slight curling of the leaves. In thus waiting for these signals of distress, both trees and fruit are liable to be injured. On the other hand, the man who ignores these symptoms and pours on a large quantity of water whenever he can spare it, or when his turn comes, is likely to cause greater damage by an overdose of water.

NUMBER OF IRRIGATIONS PER SEASON.

For nearly half the entire year the fruit trees of Wyoming and Montana have little active, visible growth, whereas in the citrus districts of California and Arizona the growth is continuous. A tree when dormant gives off moisture, but the amount evaporated from both soil and tree in winter is relatively small, owing to the low temperature, the lack of foliage, and feeble growth. A heavy rain which saturates the soil below the usual covering of soil mulch may take the place of one artificial watering, but the light shower frequently does more harm than good. The number of irrigations likewise depends on the capacity of the soil to hold water. If it readily parts with its moisture, light but frequent applications will produce the best results; but if it holds water well a heavy application at longer intervals is best, especially when loss by evaporation from the soil is prevented by the use of a deep soil mulch.

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[1] The expressions "free water" and "free moisture" here used do not include any hygroscopic moisture.

[2] U. S. Dept. Agr., Office Expt. Stas. Bul. 203.

In the Yakima and Wenatchee fruit-growing districts of Washington the first irrigation usually is given in April or early in May. Then follow three or four waterings at intervals of 20 to 30 days. At Montrose, Colo., water is used three to five times in a season. At Payette, Idaho, the same number of irrigations is applied, beginning about June 1 in ordinary seasons and repeating the operation at the end of 30-day intervals. As a rule, the orchards at Lewiston, Idaho, are watered three times, beginning about June 15. From two to four waterings suffice for fruit trees in the vicinity of Boulder, Colo. The last irrigation is given on or before September 5, so that the new wood may have a chance to mature before heavy freezes occur. In the Bitter Root Valley, Montana, young trees are irrigated earlier and oftener than mature trees. Trees in bearing are, as a rule, irrigated about July 15, August 10, and August 20 of each year.

In southern California citrus trees are watered six to seven times at regular intervals during the summer season with one to three additional irrigations in winter if cover crops are grown or if the rainfall is light. Deciduous orchards in the same locality are watered two to four times each season although occasionally one is found that receives only one irrigation, but it has been demonstrated that better results are secured with several irrigations.

DUTY OF WATER IN ORCHARD IRRIGATION.

The duty of water for 1 acre as fixed by water contracts varies all the way from one-fortieth to one four-hundredth of a cubic foot per second. In general, the most water is applied in districts that require the least. Wherever water is cheap and abundant the tendency seems to be to use large quantities, regardless of the requirements of the fruit trees. In Wyoming the duty of water is seldom less than at the rate of a cubic foot per second for 70 acres. In parts of southern California the same quantity of water not infrequently serves 400 acres, yet the amount required by the fruit trees of the latter locality is in excess of that of the former.

All over the West the tendency is toward a more economical use of water, and even in localities where water for irrigation is still reasonably low in price it is rare that more than 2½ acre-feet per acre is applied in a season. This duty was provided for in contracts of the

Bitter Root Valley Irrigation Co., of Montana, with 40,000 acres of fruit lands under ditch. Since, however the water user is not entitled to receive more than one-half of an acre-foot per acre in any one calendar month, it is only when the growing season is long and dry that he gets the full amount.

In the vicinity of Boulder, Colo., the continuous flow of a cubic foot per second for 105 days serves about 112 acres of all kinds of crops. This amount of water, if none were lost, would cover each acre to a depth of 1.9 feet. In other words, the duty of water is a trifle less than 2 acre-feet per acre.

In 1908 the depth of water used on a 21½-acre apple orchard at Wenatchee, Wash., was measured and found to be 23 inches. The trees were 7 years old and produced heavily. This orchard was watered five times, the first on May 13 and the last on September 23. In San Diego County, Cal., one miner's inch (one-fiftieth of a cubic foot per second) irrigates from 6 to 7 acres near the coast where the air is cool and evaporation low, but 20 miles or so inland the same amount of water is needed for about 4 acres.

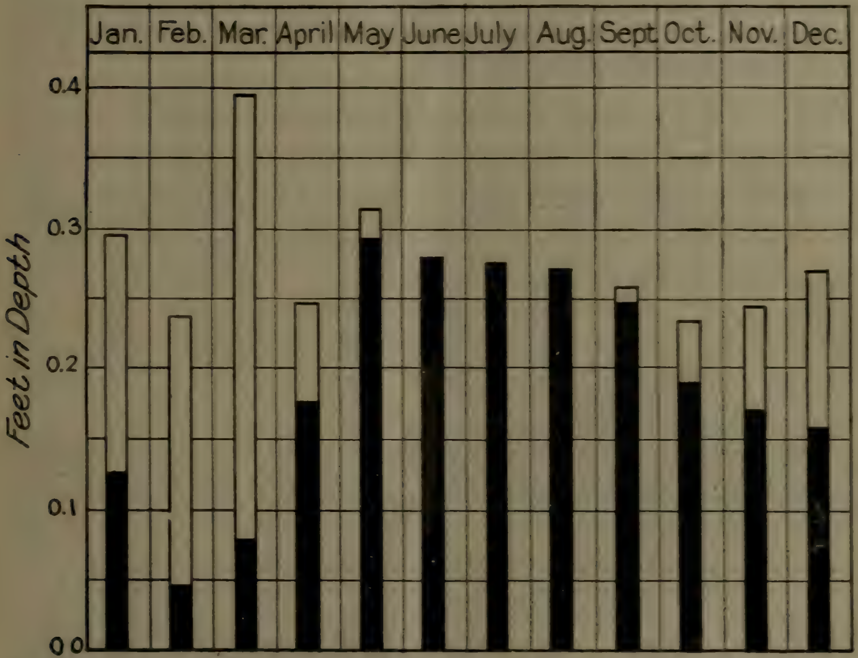

FIG. 31.—Average duty per month under Riverside Water Co., December 1, 1901, to November 30, 1908.

On the sandy loam orchards of Orange County, Cal., it has been demonstrated that 2 acre-inches every 60 days is insufficient to keep bearing trees in good condition. The rainfall of this locality averages somewhat less than 12 inches per annum, but about 95 per cent of the total falls between November and May, inclusive.

The most reliable and in many ways the most valuable records pertaining to duty of water on orchards have been obtained in southern California. Here more or less irrigation water is used every month of the year. Figure 31 is a graphic representation of the average amount of water used per month in a period of seven years by the Riverside Water Co. in irrigating about 8,400 acres, of which about 4,500 acres are planted to oranges and the remainder to alfalfa. The figures given in the diagram represent depth in feet over the surface watered. The following table gives the average duty of water per month in acre-feet per acre under the same system from December 1, 1901, to November 30, 1908, a period of seven years. The table also includes the average monthly rainfall at Riverside, Cal., for the same period, and adding the quantity of water applied in irrigation in any one month to the rainfall of that month gives the total moisture received by the soil.

Water used under Riverside Water Co.'s system (1901–1908).

Month.	Average depth per acre.	Average rainfall.	Total water applied.	Month.	Average depth per acre.	Average rainfall.	Total water applied.
	Feet.	*Feet.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*
December	0.159	0.109	0.268	July	0.272	0.002	0.274
January	.123	.170	.293	August	.269	....	.269
February	.046	.190	.236	September	.243	.015	.258
March	.078	.316	.394	October	.189	.043	.232
April	.177	.068	.245	November	.169	.073	.242
May	.291	.023	.314				
June	.274	.003	.277	Total	2.29	1.01	3.30

The duty of water for citrus orchards in the vicinity of Pomona, Cal., was ascertained on a number of typical tracts during the summer of 1905 and the results are given in the following table:[1]

Duty of water for citrus fruits at Pomona, Cal., 1905.

Number of tract.	Crop.	Acres.	Irrigations.	Hours pumped.	Rate of pumping.	Depth applied by pumping.	Total, including rainfall.
					Miner's inches.	*Feet.*	*Feet.*
1	Young oranges	70.00	4	440	16	0.2	2.5
2	.....do	10.00	7	1,560	2	.6	2.9
3	Oranges	30.00	5	550	23	.7	3.0
4	.....do	36.50	5	507	16	.4	2.7
5	.....do	60.00	5	1,100	28	.9	3.2
6	.....do	20.00	5	500	24	1.0	3.3
7	.....do	24.75	2	180	15	.2	2.5
8	.....do	8.00	6	365	7	.5	2.8
9	.....do	5.66	5	300	16	1.5	3.8
10	.....do	4.25	5	75	43	1.3	3.6
11	Oranges and lemons	35.00	5	593	29	.8	3.1
12	Lemons	15.00	6	720	12	1.0	3.3
	Average					.8	3.1

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[1] The Use of Underground Water for Irrigation at Pomona, Cal., by C. E. Tait, U. S. Dept. Agr., Office Expt. Stas. Bul. 236.

Tracts 1 and 2, being in young trees, did not require as much water as full-grown trees. Tracts Nos. 1, 2, 3, and 12 are in loose, gravelly loam near the foothills and No. 11 is in similar soil in San Dimas, Wash. Tract No. 10 is in tight soil near Spadra and the others are in the medium sandy loams near Pomona and Lordsburg. It does not appear that the unequal amounts of water applied to these tracts has been due to the different requirements of soils, but rather to the amount of water available.

For the seasons 1906, 1907, 1908, and 1909 the general duty for citrus fruit is represented by the amounts used under the systems of the Del Monte Irrigation Company and the Palomares Irrigation Company. All of the land under the Del Monte system and three-fourths of the land under the Palomares system is in citrus fruits. The results are based on the total number of hours that one or more heads of water are delivered. The average aggregate heads, in miner's inches, delivered in 1907 by the Del Monte Irrigation Company, were increased by a good supply of flowing water. An attempt is made to maintain constant heads, but usually they are slightly less than they are intended to be. This counteracts in a measure the error that would occur from making no deduction in the total acreage served by the companies for buildings and roads.

Duty of water, Pomona, Cal., 1906–1909.

DEL MONTE IRRIGATION COMPANY SYSTEM.

Year.	Acres.	Number of rotations.	Hours in schedule.	Size of stream.	Depth applied.	Total, including rainfall.
				Miner's inches.	*Feet.*	*Feet.*
1906	2,000	7	636	200	0.73	3.22
1907	2,000	7	636	300	1.10	2.98
1908	2,000	7	636	200	.73	2.19
1909	2,000	7	636	200	.73	3.39
Average					.82	2.94

PALOMARES IRRIGATION COMPANY SYSTEM.

Year.	Acres.	Number of rotations.	Hours in schedule.	Size of stream.	Depth applied.	Total, including rainfall.
1906	600	6	720	60	0.71	3.20
1907	600	7	720	60	.83	2.71
1908	600	7	720	60	.83	2.29
1909	600	7	720	60	.83	3.49
Average					.80	2.92

EVAPORATION LOSSES FROM ORCHARD SOILS.

A light shower followed by warm sunshine may refresh the foliage of fruit trees, but its effect on the soil is more likely to be injurious than otherwise. A brief, pelting rain followed by sunshine forms a crust on the surface of most soils, and if this is not soon broken up by cultivation it checks the free circulation of air in the soil and also tends to increase the amount of water evaporated.

It has been found[1] that the amount of moisture held by the soil, the temperature of both soil and air, and the rate of wind motion are the chief factors in the evaporation of water from soils. The influence of moisture is shown in the following figures, obtained from tank experiments made at Tulare, Cal., in 1904:

Evaporation from Tulare soils which received different amounts of water, June 15 to to Sept. 15, 1904.

Numbers of tanks.	Amount of water applied, inches.	Loss by evaporation.		Numbers of tanks.	Amount of water applied, inches.	Loss by evaporation.	
		Inches.	Per cent.			Inches.	Per cent.
1 and 2	0.0	0.45	....	7 and 8	6.6	5.5	83.6
3 and 4	3.3	3.5	106.0	9 and 10	8.2	6.6	80.0
5 and 6	4.9	4.6	94.0	11 and 12	9.8	7.9	79.5

The results of other experiments have shown that when the water is applied to the surface of orchard soils the loss by evaporation is very great so long as the top layer remains moist.

Even in light irrigations this loss in 48 hours after the water is put on may amount to from 10 to 20 per cent of the volume applied and from 20 to 40 per cent in the course of 3 weeks. In order to reduce this loss and moisten the soil around the roots of trees, the practice of running small streams of water in deep furrows has become quite common. In applying water in this way the topsoil remains at least partially dry, the bulk of the water soon passes beyond the first foot, and the surface can be cultivated soon after the water is turned off.

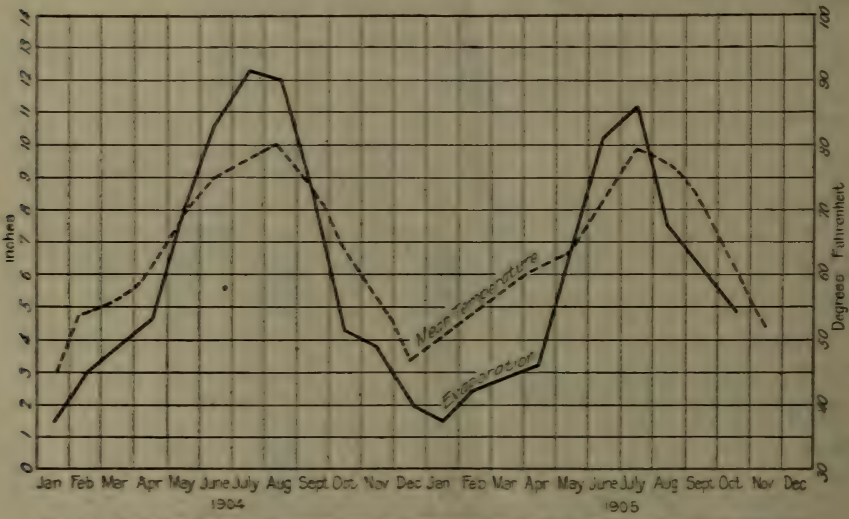

FIG. 32.—Relation between temperature and evaporation from a water surface at Tulare, Cal.

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[1] U. S. Dept. of Agr., Office Expt. Stas. Bull. 177 and 248.

However, the prevention of waste of irrigation water by evaporation from the surface of moist soil is only one factor in the profitable production of citrus fruits. If the best conditions for the tree and its fruit can be secured by other methods of applying water they should be adopted, although a part of the water supply may be sacrificed in so doing.

The well-known effect of temperature on evaporation is shown in figure 32. The dotted line shows the mean monthly temperatures at Tulare, Cal., from January 1, 1904, to December 31, 1905, and the solid line the monthly evaporation from a water surface for the same time.

EFFECT OF SOIL MULCHES IN CHECKING EVAPORATION.

Evaporation as affected by a layer of dry granular soil when placed above moist soil has been shown by a series of experiments conducted in tanks by irrigation investigations of the Office of Public Roads and Rural Engineering. These tanks are water-jacketed and placed in the open under normal conditions as regards sunshine, wind, and temperature. Each tank holds about three-fourths of a ton of soil and is weighed at stated intervals in a manner shown in figure 33.

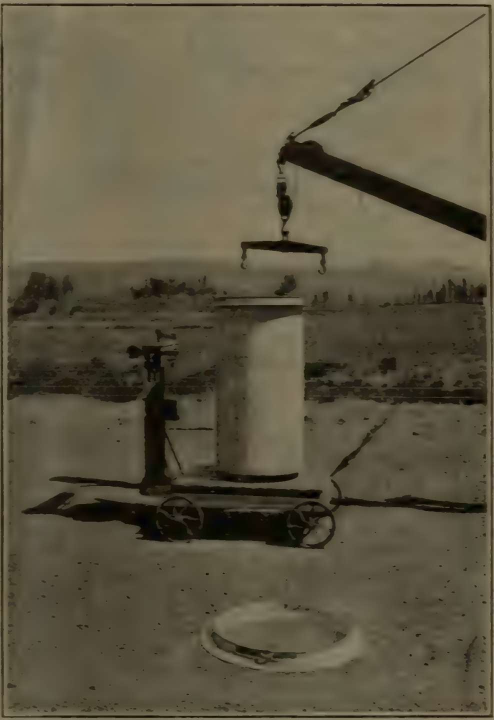

FIG. 33.—Tank experiments at Reno, Nev., to determine effect of soil mulches in checking evaporation.

At five stations in the arid region tanks containing soil were irrigated to a depth of 6 inches. After the water had disappeared entirely from the soil surface fine, dry, granular soil mulches were added as follows: Tanks 1 and 2, no mulch; tanks 3 and 4, a 3-inch layer; tanks 5 and 6, a 6-inch layer; tanks 7 and 8, a 9-inch layer. Weighings were started immediately and continued semiweekly for a period of 21 days. The average losses of water at the five stations are shown, graphically, in figure 34.

Similar equipment was used to determine the effect of cultivation in checking evaporation. The results of experiments conducted at

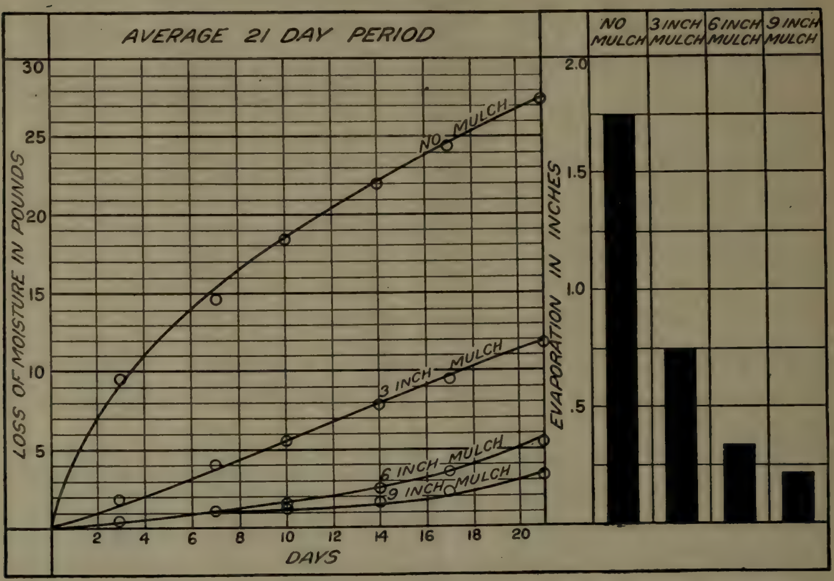

FIG. 34.—Average evaporation losses from tanks of soil protected with mulches of different depths during first 21 days after irrigation. Average of losses at five stations.

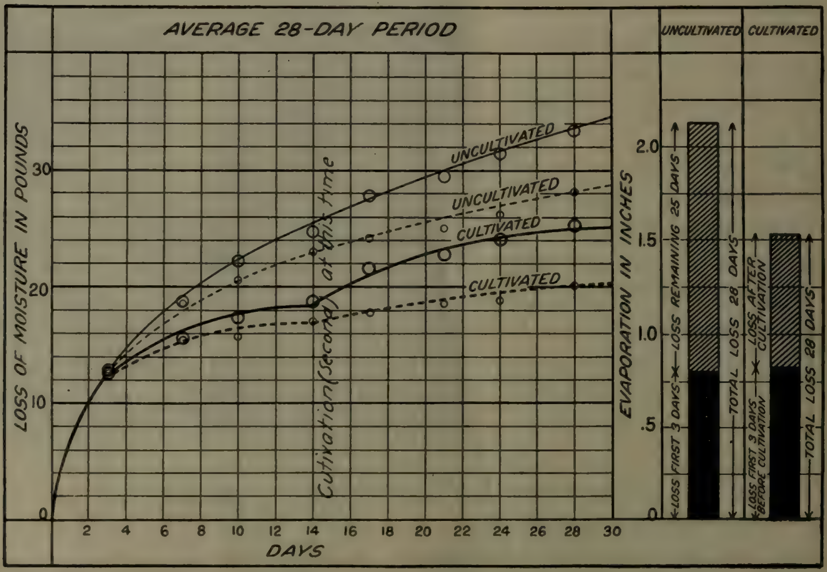

FIG. 35.—Average evaporation losses from cultivated and uncultivated tanks during first 28 days after irrigation; average of losses at six stations.

six stations in the arid region, with the accompanying meteorological data are given in figure 35. The average losses shown by the above are 2.14 inches from the uncultivated and 1.58 inches from the cultivated soils, being 35.5 and 26.3 per cent, respectively, of the total 6 inches used in irrigation. It is a significant fact that 51 per cent of the losses from the cultivated surface occurred in the first 3 days—that is, during the average period between irrigation and cultivation.

From the foregoing it is evident that western orchardists can prevent the greater part of the evaporation losses by cultivating orchards to a depth of at least 6 inches as soon as practicable after each irrigation.

LOSS OF WATER DUE TO PERCOLATION.

In the preceding paragraphs attention has been called to the large amount of water which is vaporized from warm, moist soils. The above heading calls attention to another loss of a different character. In all modes of wetting the soil, but more particularly when deep furrows are used to distribute the water, a part is likely to sink beyond the deepest roots. As a rule, the longer the furrow the greater is the loss from this cause. In furrows about one-eighth of a mile long Dr. Loughridge found in his experiments at Riverside, Cal., that in some parts of the orchard the soil was wet as a result of a recent irrigation to depths of 20 to 26 feet, while in other parts the moisture had not penetrated beyond the third foot.

One of the best ways of finding out whether much water is lost by deep percolation is to dig across trenches as deep as the feeding roots go. The moisture which passes the deepest roots in its downward course may be considered wasted.

An example of fairly even and desirable moisture distribution from furrows in orchard irrigation is shown in Sections XI and XII of figure 36, where the three curved lines show the margins of the wetted soil at the end of 1, 2, and 3 days, respectively. This diagram, likewise, shows that the irrigation is defective in having dry spaces between Sections IV and V, X and XI, and XII and XIII. Since the lateral movement of moisture in soils proceeds very slowly after the third day from an irrigation, it is doubtful that these dry spaces receive much water from the adjacent furrows.

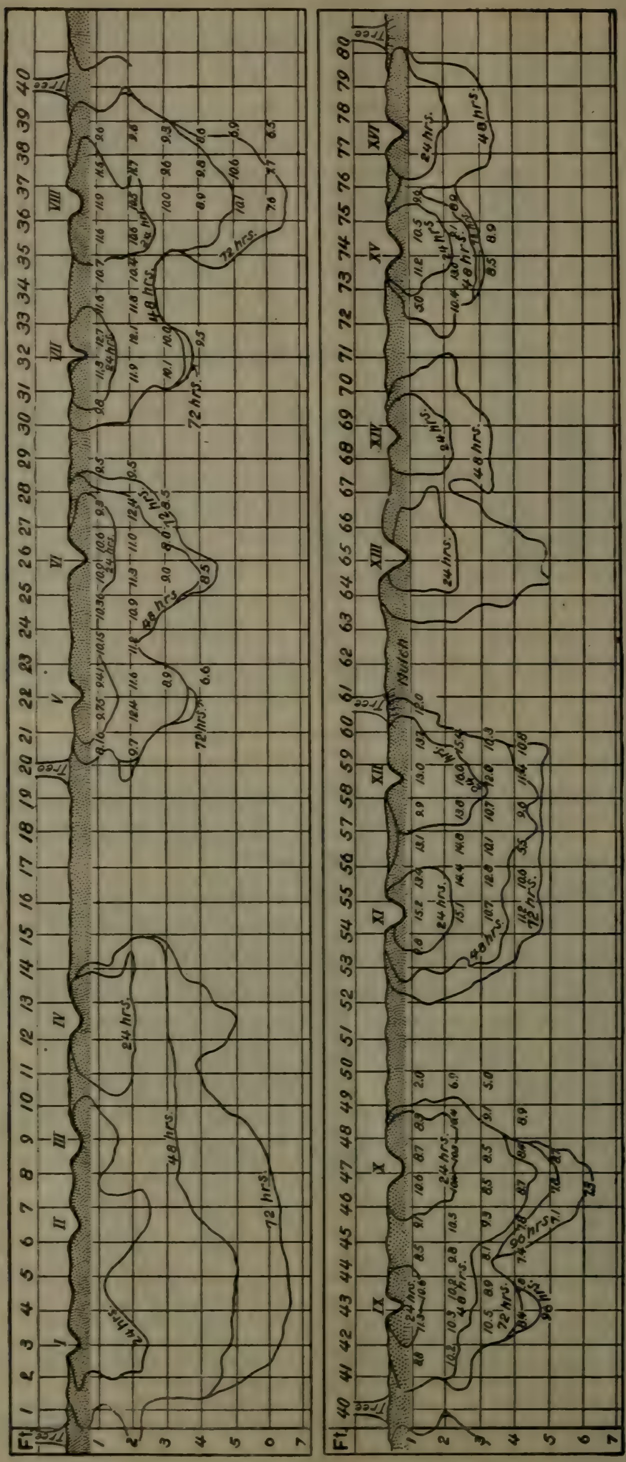

FIG. 36.—Outlines of percolation under 16 furrows in orchard 58 under the Gage Canal Co., Riverside, Cal.

Summary of temperature of air, soil, and water, humidity, wind velocity, rainfall, free water in soil, and losses from free-water surface and from cultivated and uncultivated tanks at the several stations.

Stations.	Number of trials.	Temperatures.				Humidity.	Average wind velocity per hour.	Total rainfall.	Free water in soil.	Evaporation from free-water surface.	Loss from cultivated soils.	Loss from uncultivated soils.	Saved by cultivation.
		Atmospheric.	Cultivated soil.	Uncultivated soil.	Water.								
		° F.	° F.	° F.	° F.	P. ct.	Miles.	In.	P. ct.	In.	In.	In.	P. ct.
Sunnyside, Wash......	1	65.2	71.3	74.3	70.9	......	......	0.00	6.00	7.25	1.47	2.47	40.3
Davis, Cal.............	2	64.5	......	75.7	73.2	49.8	9.3	.00	12.85	9.41	1.36	1.91	28.2
Reno, Nev.............	2	56.6	......	67.9	......	58.9	6.4	.39	8.88	8.49	1.09	1.51	27.8
Caldwell, Idaho........	2	72.2	69.2	69.4	68.4	......	......	.14	6.21	9.81	1.91	2.42	21.0
Agricultural College, N. Mex...............	2	74.5	......	......	......	22.7	8.3	.57	......	11.13	1.37	1.59	13.8
Bozeman, Mont.......	1	64.4	73.9	74.6	75.0	......	9.4	.99	17.80	4.38	2.30	2.92	21.2
Average.........	....	66.2	71.5	72.4	72.9	43.8	8.4	.35	10.35	8.41	1.58	2.14	26.4

REMOVAL OF WASTE WATER.

Loss of water is not the only effect of deep percolation. The water which escapes in this and other ways usually moves through the soil slowly until it reaches some underground body of water at a lower level. In case orchards have been planted at these lower levels when the subsoil was dry, care should be exercised in observing the rise of the ground-water level. The small post-hole auger shown in figure 37 is one of the most convenient tools to use in making test wells to keep track of the behavior of the ground water. Before the deepest roots of the fruit trees are submerged artificial drainage ought to be provided. Otherwise the ground water will at first lessen the yield and finally destroy the trees.

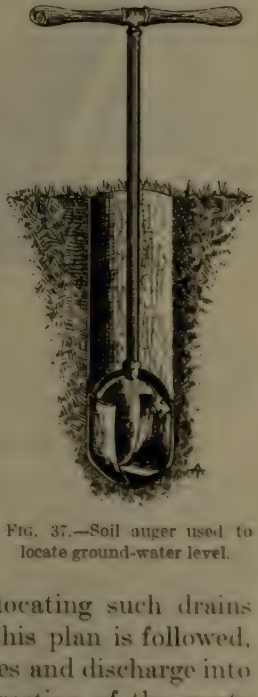
FIG. 37.—Soil auger used to locate ground-water level.

The drainage of orchard tracts usually progresses in more or less distinct and separate stages. When the ground water begins to be a menace, the natural ravines in the vicinity are cleared of weeds and other rubbish and deepened. If the ground water continues to rise, the open drains are deepened and extended or else the excess water is withdrawn through covered drains. Open drains in orchards occupy valuable land, obstruct field work, and are expensive to maintain. Some of these objections can be lessened if not removed by locating such drains along the lower boundary of the tract. When this plan is followed, covered drains frequently are laid among the trees and discharge into the open drains. Sometimes the source and direction of the waste water which is waterlogging an orchard can be traced beneath the surface. In this event it is well to try to intercept its passage before it reaches the trees. This can be done by an open drain, but a covered pipe drain of the required size is preferable. Where durable lumber is cheap, box drains similar to that shown in figure 38 may be used. Where lumber is high in price, it will be more economical to use pipe drains made of either clay or cement. The former is most frequently used for sizes ranging from 4 to 8 inches in diameter and the latter for sizes 10 inches and over. The clay or tile drains are made 1 foot in length, but in using cement for the larger sizes the length may be increased to 2 and even 3 feet.

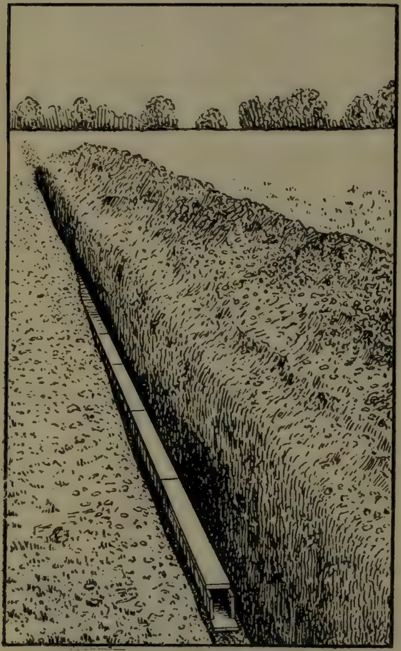
FIG. 38.—Box drain.

The drainage of irrigated lands differs in many respects from that common to the humid States of Iowa, Illinois, or Ohio. In irrigated districts the drains are larger and are laid deeper. While 4-inch tile drains may be used in places, 6-inch drains are to be preferred, and should be considered as the smallest desirable size. The depth at which they are laid ranges from 5 to 7 feet, and a minimum of 5 to 6 feet is required for orchards. A grade of 5 feet to the mile is about the least that should be used, and wherever practicable it should be increased to 10 feet to the mile.

In laying drains that are likely to become clogged with silt or roots, or both, a small cable is laid in each line, and at distances of 300 to 500 feet sand boxes similar to figure 39 are placed so as to facilitate cleaning the tiles with suitable wire brushes.

INFLUENCE EXERTED BY TIME OF IRRIGATION.

In 1911 cooperative irrigation investigations were begun in Utah by W. W. McLaughlin, of the Office of Public Roads and Rural Engineering, to determine the influence exerted on peach trees and fruit by varying the time of irrigation. This work was continued until the close of the season of 1914 and the results summarized by L. D. Batchelor in Bulletin 142 of the Utah Agricultural Experiment Station. From this summary the following conclusions are drawn:

1. Frequent applications of irrigation water applied to peaches on a gravel loam soil at intervals of 7 or 8 days produced a more continuous and greater total twig growth than the same total amount of water applied with larger aplications at intervals of every 10 to 12 days. The more porous the soil the more frequently the trees should be watered.

2. With varying times of application of irrigation water the season of most rapid twig growth is during the season of watering.

3. A total application of irrigation water of 21 acre-inches per acre on a gravel loam soil produced a total twig growth practically equal to that produced by 62 acre-inches of water per acre.

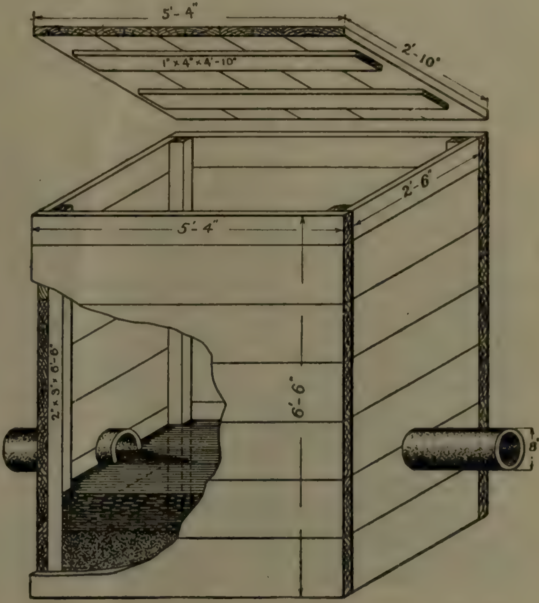

FIG. 30.—Sand box in tile line.

4. With the same total amount of water applied on a gravel loam there is a regular increase in crop production the more frequent the irrigation. Less water was evidently lost by seepage when irrigation water was applied every 7 or 8 days and the trees received no check in growth due to becoming excessively dry from one watering to another.

5. The maximum duty of irrigation water applied to peaches on a gravelly soil was 31 acre-inches per acre during the years 1913 and 1914. Sixty-two acre-inches of water applied to 2 acres on a gravel loam soil would apparently have produced twice the yield of marketable fruit than if applied to 1 acre of trees.

6. No amount of water applied early in the season to a crop of peaches on a gravelly soil will compensate for the lack of water during the month before harvest.

7. There is no marked variation in the color of the fruit on the plots receiving a large amount of irrigation water when compared with plats receiving only a medium amount of water. Poor color of the fruit was associated with a small amount of irrigation water.

8. High coloration of the peach was associated with late watering.

WINTER IRRIGATION OF ORCHARDS.

When water is used outside of the regular irrigation period or, what is in many cases equivalent, outside of the growing season, it is termed winter irrigation. Over a large part of the arid region the growing season is limited by low temperatures to 150 days, or less, and when the flow of streams is utilized only during this period much valuable water runs to waste.

For the purpose of utilizing some of this waste the orchardists of the Pacific Coast States and Arizona began the practice of winter irrigation. The precipitation usually occurs in winter in the form of rain, and large quantities of creek water are then available. This water is spread over the orchards in January, February, and March, when deciduous trees are dormant. The most favorable conditions for this practice are a mild winter climate; a deep, retentive soil that will hold the greater part of the water applied; deep-rooted trees; and a soil moist from frequent rains.

The creek water that was applied to some of the prune orchards of the Santa Clara Valley, Cal., during the winter of 1904 was measured by the agents of this office, with the following results: From February 27 to April 23, 1,241 acres were irrigated under the Statler ditch to an average depth of 1.58 feet. From February 12 to April 23, 2,021 acres were irrigated under the Sorosis and Calkins ditches to an average depth of 1.75 feet. In the majority of cases the orchards which are irrigated in winter in this valley receive no additional supply of moisture other than about 16 inches of rain water.

In the colder parts of the arid region winter irrigation is likewise being practiced with satisfactory results The purpose is not only to store water in the soil but to prevent the winterkilling of trees. Experience has shown that it is not best to apply much water to orchards during the latter part of the growing season, since it tends to produce immature growth which easily is damaged by frost. In many of the orchards of Montana no water is applied in summer irrigation after August 20. Owing, however, to the prevalence of warm chinook winds, which not only melt the snow in a night, but rob the exposed soil of much of its moisture, one or two irrigations are frequently necessary in midwinter.

GRAINS FOR THE UTAH DRY LANDS

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FARMERS' BULLETIN 883

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. October, 1917

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1917

UTAH soils in general are suitable for dry farming, and the rainfall usually is sufficient to grow one crop in two years. The principal crop is winter wheat, which is grown in alternation with summer fallow. Winter emmer, barley, and oats and spring barley and oats also may be grown.

To produce the best yields of winter wheat and other grains at the least expense, plow the land in the spring and maintain a clean fallow during the summer. Sow between September 15 and October 15 at a depth of 2 to 3 inches. Sow winter wheat at the rate of 5 pecks and winter emmer, oats, and barley at from 6 to 8 pecks per acre. Spring wheat, oats, and barley, where it is necessary to grow these crops because of the failure of fall-sown grains, should be sown as early in the spring as the land can be put in condition for seeding.

The best varieties are Crimean, Turkey, and Kharkof winter wheats, Black Winter emmer, Boswell Winter oats, and White Club and Tennessee Winter barleys. Of the spring varieties the best are Ghirka Spring and Marquis wheats, Swedish Select oats, and Coast, Mariout, and White Smyrna barleys.

Corn, the grain sorghums, proso, and flax have been grown in a very limited way and can not be recommended generally. Corn and the grain sorghums may prove to be of value in certain localities.

GRAINS FOR THE UTAH DRY LANDS.

CONTENTS.

	Page.		Page.
Dry-land sections of Utah	3	Grain crops and varieties—Continued.	
Dry farming in Utah	6	Emmer	18
Dry-farm crops	7	Oats	18
Growing the grain crops	7	Barley	19
Grain crops and varieties	14	Minor grain crops	20
Wheat	14		

DRY-LAND SECTIONS OF UTAH.

DURING the last 15 years the dry lands of Utah have been rapidly taken under the homestead law or have been bought from the State. Most of this land is owned by people who were either unable to obtain irrigated land or who wanted a dry farm in addition to their irrigated land. The first few years that dry farming was practiced profitable crops were not produced every year. Failures were not infrequent, but thorough tillage and careful observation finally made dry farming a success. Many of the practices, however, were based on theories rather than on fundamental principles evolved from carefully conducted experiments. Reliable information regarding the best crops and the methods of growing them on dry farms has always been in demand.

This bulletin presents the best available information on the small-grain crops and varieties adapted to Utah dry lands and the cultural operations necessary to produce them. The information is based largely on experiments conducted during the last nine years at the Nephi substation.[1] This substation is located in the Juab Valley, in Juab County, which is about the geographical center of the State. The principal crops discussed are winter wheat, spring wheat, emmer, oats, and barley.

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[1] The Nephi substation was established in 1903 by the Utah Agricultural Experiment Station. Since 1907 the experiments there have been conducted cooperatively by the Utah station and the Bureau of Plant Industry of the United States Department of Agriculture. These experiments have been reported in detail in the following publications:

Farrell, F. D. Dry-land grains in the Great Basin. U. S. Dept. Agr., Bur. Plant Indus. Circ. 61, 39 p., 2 pl. 1910.

Cardon, P. V. Cereal investigations at the Nephi substation. U. S. Dept. Agr. Bul. 30, 50 p., 9 fig. 1913.

——— Minor dry-land crops at the Nephi experiment farm. Utah Agr. Exp. Sta. Bul. 132, p. 347–378, 7 fig. 1914.

——— Tillage and rotation experiments at Nephi, Utah. U. S. Dept. Agr. Bul 157, 45 p., 21 fig. 1915.

Harris, F. S., and Ellison, A. D. Dry farming in Utah. Utah Agr. Exp. Sta. Circ 21, 35 p., 15 fig. 1916.

The dry-land sections of Utah are not located in any distinct geographic portion of the State. The whole State is naturally arid. A small percentage of the land can be reclaimed by irrigation; the remainder, if farmed at all, must be cropped by dry-farming methods. The acreage adapted to dry farming is limited, however, as a large part of the State is mountainous. In many districts which are otherwise arable the annual precipitation is so low that they can not be farmed successfully except by irrigation. The lower lands in the mountain valleys are usually irrigated if the water supply is sufficient, while the lands above the canals must be dry farmed or not farmed at all.

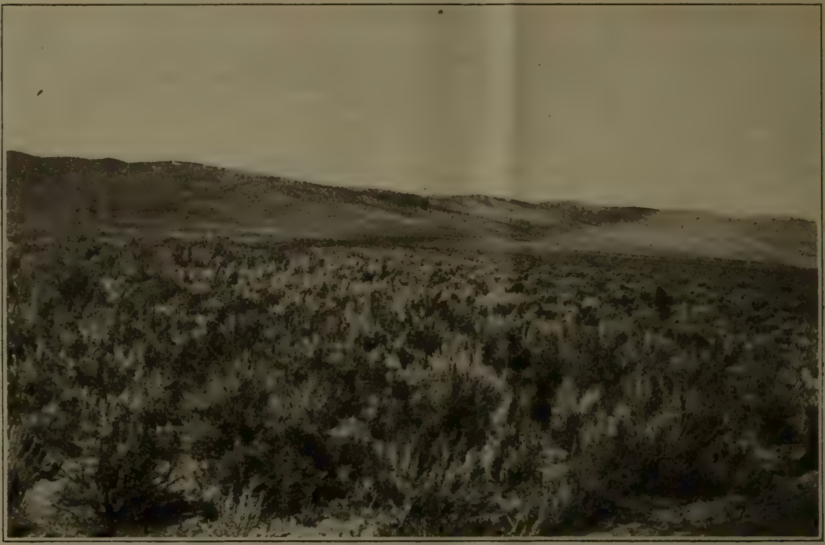

FIG. 1.—A typical Utah mountain valley landscape, showing land suitable for dry farming. The abundant growth of sagebrush indicates a fertile soil and a rainfall sufficient for crop production if properly utilized.

TOPOGRAPHY.

Most of the land in the State where the rainfall is sufficient to mature one crop in two years and that is not too rough for the ordinary cultural operations is dry farmed. Usually this land is above "high-line" canals or is so located that irrigation is otherwise impossible. Much of this dry-farmed land is quite smooth, with a gradual slope toward the center of the valley. In some sections, however, the land is badly broken by ravines; in others, hills and hollows are numerous. A typical landscape in a Utah mountain valley is shown in figure 1. The abundant growth of sagebrush shown in this illustration indicates a fertile soil and a rainfall sufficient for crop production if properly utilized.

SOILS.

The soil types in the State vary from light sand to heavy clay, with clay loam predominating. Considerable acreages of sandy soil will never be successfully dry farmed because of low moisture-holding capacity, high evaporation, and low precipitation. Neither are the heavy clays ideal for dry farming, because of their hardness, tendency to bake, and lack of response to cultural operations. The most nearly ideal dry-farm soil is one which is uniform to a considerable depth, with enough sand to make it easily tillable and enough clay to insure the retention of sufficient moisture for crop production. Utah has a large acreage of just such soils, unbroken by gravel or hardpan. The fertility of these soils is best shown by their crop production in normal years. Because of the low rainfall the mineral elements of plant food naturally in the soil have not been removed by leaching. Crop production on these soils is limited only by the available water.

CLIMATE.

Climatic conditions vary in different parts of Utah. In the southern part of the State the growing season is longer than in the north; in fact, rather wide variations often occur in a single mountain valley. Canyon breezes and good air drainage help to prevent frost injury in some locations when in other near-by locations frost damage is severe.

RAINFALL.

Successful and profitable crop production on arid land depends largely on the amount and distribution of the rainfall. About 85 per cent of the annual precipitation in Utah falls between October and April. As the bulk of the precipitation comes during the winter and early spring months, this moisture must be stored in the soil if it is to be of use to growing plants. A low annual precipitation favorably distributed is often more efficient than a high precipitation poorly distributed.

The annual rainfall in Utah varies from 3.71 inches at Wendover, Tooele County, to 19.30 inches at Henefer, Summit County. At Nephi the average annual precipitation for the past 19 years is 13.56 inches. In Tooele County the precipitation varies from 3.71 inches at Wendover to 15.93 inches at Lovelle; in Box Elder County, from 6.5 inches at Kelton to 12.5 inches at Corinne. These examples clearly show the marked variations that occur in the precipitation in a relatively small area; hence the necessity of knowing the distribution of the normal precipitation for each locality.

EVAPORATION.

Evaporation is an important factor in crop production on the dry lands. A section with high evaporation and high precipitation may not produce any better crops than a section with a low evaporation and low precipitation, other conditions being equal. Evaporation in a measure determines the efficiency of the precipitation. The evaporation in Utah is rather high, so that a relatively high precipitation or a soil with good moisture-holding capacity is necessary for profitable crop production. The evaporation from a free water surface at the Nephi substation for the seven months from April to October, inclusive, has averaged 48.9 inches during the past nine years. This is about the same as the average evaporation for the same months in the central Great Plains and in the Columbia Basin.

TEMPERATURE.

The temperature varies in different parts of the State, being lower at the higher than at the lower elevations. The annual mean temperature, based on records from 26 stations, is about 49.5° F. The annual mean temperature ranges from 43.6° at Emery, located on the western edge of Emery County, at an elevation of 6,260 feet, to 59.8° at Hite, on the Colorado River, in Garfield County, at an elevation of 3,000 feet. Temperatures well below zero are usually recorded at intervals during the winter months. Minimum temperatures as low as —25° and —30° F. are sometimes recorded at the higher elevations. Maximum temperatures of 100° F. or more are sometimes recorded during June, July, and August, especially at the lower elevations.

The frost-free period varies from year to year and also varies widely with the altitude. The growing season is comparatively short, the period from the last frost in spring to the first frost in fall usually ranging from 110 to 150 days. At Nephi the average frost-free period is 104 days, with a minimum in the past nine years of 69 days and a maximum of 142 days.

DRY FARMING IN UTAH.

Utah is usually looked upon as the pioneer State in dry farming. Attempts at dry farming were made soon after 1850, but little success was attained until about 1890 or later. In 1903 experimental work in dry farming began in Utah.

Lack of irrigation water and the slow development of irrigation projects forced the earlier settlers to the dry lands. The change in the homestead law which allows the taking up of 320 instead of 160 acres added impetus to the dry-farm movement. The land suitable for dry farming has been rapidly settled during the past decade. A large part of the tillable dry land in Utah has been brought under cultivation, especially that which lies close to railroads and markets. There is still considerable land in isolated sections that may in time be profitably cultivated. As land becomes scarcer the home seekers are forced farther and farther into these isolated districts. The best lands are taken, so that one's choice is now limited. The problem confronting the dry farmer is not one of using good judgment in selecting his farm. but of making the best of the conditions as he finds them.

DRY-FARM CROPS.

Winter wheat always has been and probably always will be the leading crop grown on the Utah dry farms. It is admirably adapted to the system of alternate cropping and fallowing as practiced in Utah. It has a higher value per unit of bulk than other dry-land crops. It is easily transported, is always marketable, and gives a ready cash return. The growing of oats, barley, and other feed crops has increased as the live stock on the farms have increased. Further diversification of crops on the Utah dry farms is practically impossible, because winter wheat is the only profitable crop that is generally adapted to the dry lands. Other crops may be profitable in some sections.

GROWING THE GRAIN CROPS.

It is impossible to give definite directions for growing cereals over an extensive area, because of soil and climatic variations. The directions herein given for growing cereals on the Utah dry farms are general rather than specific and must be modified by local conditions and experience.

PREPARATION OF THE SEED BED ON NEW LAND.

Virgin land in Utah is usually covered with a growth of sagebrush. Special implements for removing this brush are manufactured, but none of them is entirely satisfactory because (1) they are too expensive and (2) they do not always do good work. "Railing" is the most satisfactory method of clearing brush land. When the brush is dry, two railroad rails, one fastened behind the other, are dragged over the land two or three times. This breaks most of the sagebrush and it can then be gathered into windrows with a spike-tooth harrow or an ordinary hayrake and burned. The use of the spike-tooth harrow in completing the clearing of brush land is shown in figure 2. The best time to do the work is in the fall. New land may be plowed either in the spring or in the fall. The plowing should be from 5 to 8 inches deep. If plowed in the fall the land should be left rough until spring. Clean cultivation during the summer will put it in good condition for fall seeding. If the land is spring plowed and is to be sown to grain the following fall it must

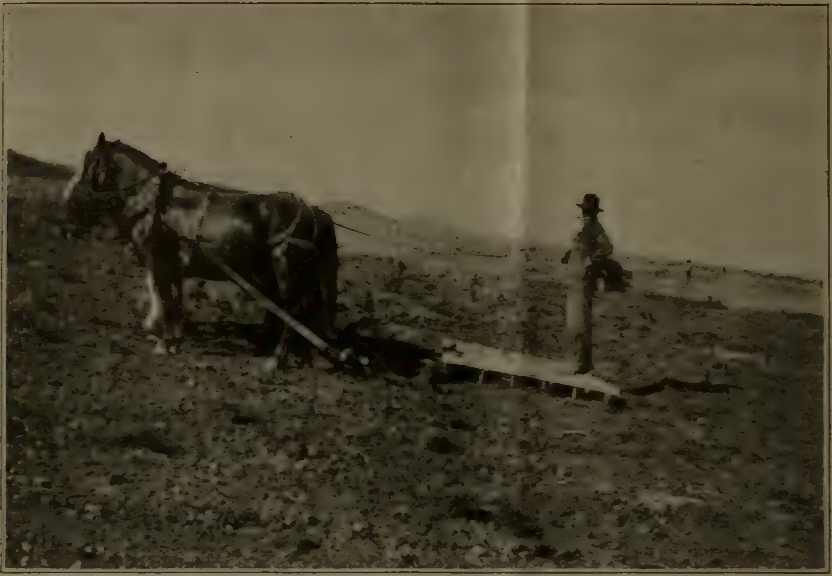

FIG. 2.--Removing with a spike-tooth harrow the last of the sagebrush roots from a field, preparatory to breaking for wheat.

be worked down immediately after plowing and kept free from weeds until seeding time. Disking and harrowing are the most effective operations in preparing land for seeding. Except in localities of high rainfall or in wet seasons it is not advisable to seed the same year that the land is broken. It should be fallowed one season to insure the storage of sufficient moisture for crop growth.

PREPARATION OF THE SEED BED ON STUBBLE OR OLD LAND.

Old land may be plowed either in the fall or spring. On large farms it is good management to plow part of the land in the fall and the remainder in the spring, thus keeping the farm equipment busy. Land that is to be seeded in the spring should be fall plowed and left rough during the winter. The rough, cloddy surface helps to catch and hold the moisture. This land works down readily in the spring. The land should be plowed 5 to 8 inches deep. Plow only when the land is in good condition for the work. Good plowing does not necessarily mean deep plowing, but means that the land should be turned evenly, covering all trash, weeds, and stubble. Results at the Nephi substation show that deep plowing is not essential to success on Utah dry farms; in fact, subsoiling is distinctly unprofitable. A traction engine with 12 disk plows attached at work in a stubble field is shown in figure 3.

Spring plowing for fallow at Nephi has been found more profitable than fall plowing. Spring-plowed land should be harrowed as soon as possible after plowing, preferably the same day it is plowed.

Spring plowing for fallow should be done as soon as weeds and volunteer grain begin growth, thus eliminating the weed problem to a large extent. The disk and spike-tooth harrows are the most commonly used implements on plowed land. Do not use the disk harrow too often: frequent use fines the surface soil too much. In killing weeds some kind of knife weeder or spring-tooth harrow should be used. Floats are used to level the land before sowing.

A firm seed bed with a fine mellow surface to a depth of 2 to 3 inches is best. The disk harrow, except when used for packing, causes the soil to dry to too great a depth. If spring plowing is to be sown to spring crops, disk to pack the land and then harrow as soon as possible. If the spring-plowed land is intended for fall-sown grain, harrow after plowing. Disking is not necessary, as the summer rains will pack the land sufficiently before fall seeding.

Unsupported theory has no place in farm practice. Returns count. At Nephi, spring plowing is cheaper than fall plowing, because (1) it eliminates weeds and volunteer grain, thus reducing the cost of maintaining the fallow; (2) yields on spring plowing are as high as those on fall plowing; (3) land is in better condition for plowing in the spring than in the fall; and (4) average results in the past eight years show that more moisture has been stored in the upper 6 feet in spring-plowed than in fall-plowed plats.

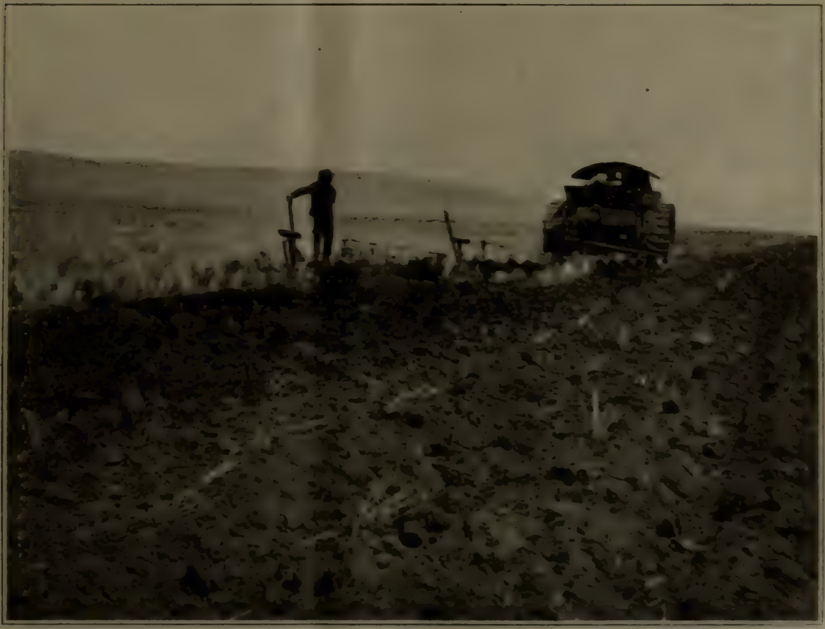

FIG. 3.—Breaking stubble land for fallow with a traction engine and disk plows on a Utah dry-land farm.

SUMMER FALLOW.

Summer fallowing has been practiced in Utah since the earliest days of dry farming in the State. Fallow land is plowed in the fall or spring and by cultivation is kept free from all growth during the fallow season. The purpose of fallow is to store moisture for the crop that is to follow. This is an expensive practice, but in Utah it is necessary in most of the dry-farmed sections. Alternate fallow and cropping is the usual practice. Experimental results at Nephi show that fallowing every third year gives better returns than fallowing in alternate years. In sections with a precipitation of 15 inches or more, fallowing every third year is probably sufficient. Land that is to be spring plowed for fallow should be plowed as soon as the weeds and volunteer grain start growth. Harrow immediately after plowing. Use a knife weeder to eradicate scattered weeds that may appear later in the season. It is better to grow a crop of wheat than a crop of weeds. Do not pulverize the soil too much by frequent cultivation. Keep a clod rather than a dust mulch on the surface. Clod mulches blow less and are less likely to puddle than dust mulches. The purpose of a fallow is to store moisture. Moisture is not saved on a weedy fallow.

Late spring plowing results in the loss of much moisture by allowing plant growth. Fall plowing for fallow is probably advisable in some localities. It should be left rough until spring and then cultivated with the disk and spike-tooth harrows to kill weeds and conserve moisture. Weeds are most easily killed when they are young.

In some dry-farmed sections tilled crops are good substitutes for fallow in alternation with the small grains. Where winter wheat is important the cultivated crops do not lend themselves so readily to such a system. On the dry farms, winter wheat is usually sown early, before the cultivated crop is ready for harvest. With spring-sown cereals the tilled crop fits in much better. Winter wheat is the leading crop on the Utah dry farms, and no profitable tilled crop has yet been found to replace the fallow. Corn does well on some of the light dry-farm soils, but it is not commonly grown as a substitute for fallow. The average yields of winter wheat grown after peas, corn, and potatoes were almost identical with the yields of that grown after fallow at the Nephi substation. These tilled crops, however, were not profitable in themselves. Where tilled crops are grown the land merely is disked before seeding to a cereal crop. This cheap seed-bed preparation for the cereal helps to reduce the cost of the practice. Fallowing, although expensive, is less expensive than growing tilled crops, including the cost of seed and the labor of sowing and harvesting.

GOOD SEED.

CLEANING AND GRADING.

Low yields are often due to the use of poor seed. The use of good seed pays. Only plump well-filled grain should be sown. The seed grain should be carefully graded with a fanning mill, and trash, weed seeds, broken and shriveled kernels and smut balls removed. Use only those varieties that are known to be adapted to your locality. Then use the best seed of the best known variety. Do not sow irrigated varieties on dry land or spring varieties in the fall. Use as nearly pure seed as possible; mixtures ripen unevenly and loss from shattering during harvest results. Mixed wheat is often docked on the market, especially if the mixture consists of hard and soft varieties.

Farmers often remark that their seed is running out and that they need a better grade of seed from some outside source. Experiments at the Nephi substation show that wheat grown at Nephi is as good for seed as wheat shipped in from Oregon or Montana. It is true that crops deteriorate if not properly cared for, but grain does not run out if selected and graded before sowing. Local seed should become more valuable each year that it is grown. Many experiments show that yellow berry can not be controlled by selection. This inferior quality is due to a combination of climatic and soil conditions.

TREATING THE SEED FOR SMUT.

The most common diseases of cereals in Utah are the smuts. The cereal smuts can be controlled to a large extent by treating the seed. The most common smuts are the stinking smut of wheat, the smut of oats, and the covered smut of barley. The formaldehyde treatment is the one most frequently used to combat these diseases. The proper strength of the solution is 1 pound of 40 per cent commercial formaldehyde to 40 gallons of water. The formaldehyde may be purchased at any drug store Either of the three following methods is effective:

(1) After running seed grain through a fanning mill to remove smut masses, spread it on a clean floor or a tarpaulin and sprinkle the formaldehyde solution over the grain. The grain should be stirred thoroughly while being sprinkled, and the process should be continued until every kernel is wet. Then cover the grain with a canvas or some other heavy material and allow it to lie one hour. It should then be uncovered and stirred occasionally until dry. It is then ready for seeding.

(2) Prepare the formaldehyde solution in barrels. Put the grain to be treated in burlap sacks after it has been fanned to remove smut masses. Fill the sacks about half full and immerse them in the solution for 10 minutes; then hang them up to drain and dry. The sacks should be shaken occasionally to hurry the drying process.

(3) When all the smut balls are not removed by the fanning process it is advisable to immerse the seed in a formaldehyde solution. There are several

methods of doing this, one of the most convenient of which is as follows: A hole is bored in the side near the bottom of each of two tubs or half barrels with handles. This hole is fitted with a plug and covered with a wire screen on the inside of the tub, so that grain can not pass through. One tub is set above the other. The upper tub is then filled two-thirds full with the formaldehyde solution and the seed poured in. As the seed is poured in and stirred, smut balls, chaff, and light kernels rise to the surface and are skimmed off. When the skimming is completed the plug is removed, and the formaldehyde solution is allowed to drain into the tub beneath. The grain is then removed and spread out to dry. The empty tub is placed on the ground, the other tub on the stand, and the process is continued, more of the solution being added when necessary.

A convenient modification of this method is to provide two tubs, a large one and a smaller one, the latter made of substantial wire mesh or of iron or tin with perforated plate or wire bottom. The larger tub is two-thirds filled with the formaldehyde solution; the other tub is set down in it and the grain poured in and stirred. The smut balls and foreign material will rise to the surface and can be skimmed off. When this is done the smaller tub containing the grain can be removed from the solution, which is allowed to drain off, and the grain is emptied on the floor and dried.

In treating grain, care should be taken to have the solution the right strength. If too weak, it will not kill the spores. If too strong, it will injure the grain. Be sure the formaldehyde you buy is full strength. Wash out the drill with the formaldehyde solution. This

FIG. 4.—Harvesting wheat with a large combined harvester and thrasher on a Utah dry-land farm.

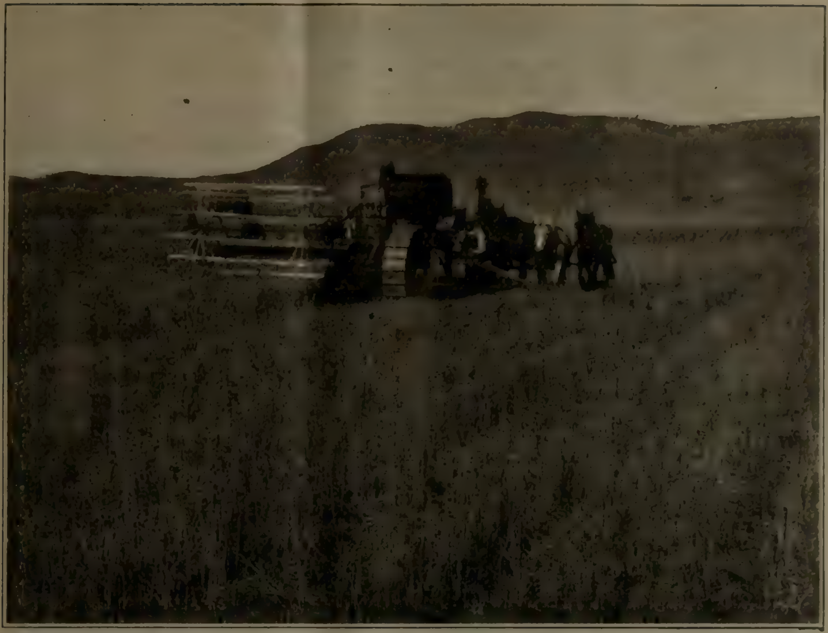

FIG. 5.—Harvesting wheat with a small, or "Idaho," combined harvester and thrasher on a Utah dry-land farm.

will destroy any smut spores that may be in it. For a more complete discussion of the smuts of grain and of smut treatments, see Farmers' Bulletin 507, "The Smuts of Wheat, Oats, Barley, and Corn."

SEEDING.

The best rates, dates, and methods of seeding the various small grains will be discussed for each crop separately in the pages which follow.

HARVESTING.

The grain crops are usually harvested in one of three ways—(1) with combines, (2) with headers, or (3) with binders.

The combines are not used extensively in Utah, though conditions are favorable for their use. Grain must be fully ripe before it is harvested with a combine, but standing grain in this State is not likely to shatter or be damaged by hail, rain, or wind storms. Combines in the past have been large, expensive machines, and were practical only on the large farms. Small combines are now being manufactured, which undoubtedly will be more popular in Utah than the big ones have been. A large combine in operation is shown in figure 4 and a small one in figure 5.

Most of the wheat in Utah is cut with headers. These machines cut off the heads and elevate them directly into header boxes, from which they are stacked. A header in operation is shown in figure 6 and stacks of headed wheat in figure 7. Stacks should be well built to shed rain. The advantages of the header are:

(1) It leaves most of the straw on the ground.
(2) Large acreages can be harvested quickly.
(3) Thrashing can be done when other work is slack.
(4) The field is ready for plowing or other cultivation early in the season.
(5) Grain can be hauled directly from the thrasher to the elevator without being sacked.

These are points that are worthy of attention when methods of harvesting are being considered. Oats are usually cut with the binder rather than the header, as much of the grain is lost by shattering if this crop is left until ripe enough to harvest with the header.

Thrashing from the shock is more expensive than thrashing from the stack. The binder is useful on small fields, but it is not as suitable for harvesting in Utah as the header or small combines.

GRAIN CROPS AND VARIETIES.

WHEAT.

Wheat is the most important dry-farm crop in Utah. The climate and soil are generally favorable for wheat growing. There is always a ready market for wheat, and it is the best adapted cash crop on the dry farms. It has a relatively high value per unit of bulk and is easily and cheaply handled. For these reasons it can be profitably grown at a considerable distance from market. In 1916 there were 326,000 acres of wheat grown in Utah. This area produced 6,900,000 bushels of wheat.

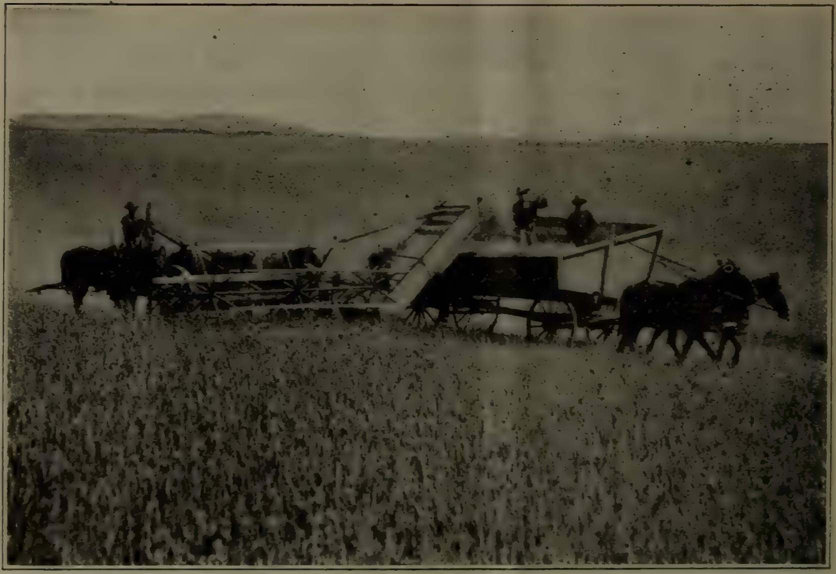

FIG. 6.—Cutting wheat with a header in Utah.

WINTER WHEAT.

In 1916 there were 5,000,000 bushels of winter wheat produced in Utah, as compared with 1,900,000 bushels of spring wheat. The average production of winter and spring wheat in the State in the five years from 1911 to 1915, inclusive, was 4,628,000 and 1,973,000 bushels, respectively. Winter wheat is adapted to practically all sections of the State. Winterkilling occurs in some districts, but where it can be grown winter wheat yields considerably more per acre than spring wheat. Most of the spring wheat is grown under irrigation, but when fall wheat winterkills on the dry farms the land is often reseeded to spring wheat. Winter wheat matures from 10 days to 2 weeks earlier than the spring varieties. Its earliness often enables it to escape the most serious effects of summer droughts, which seriously injure spring wheat. Winter wheat stands up better than spring wheat on Utah soils.

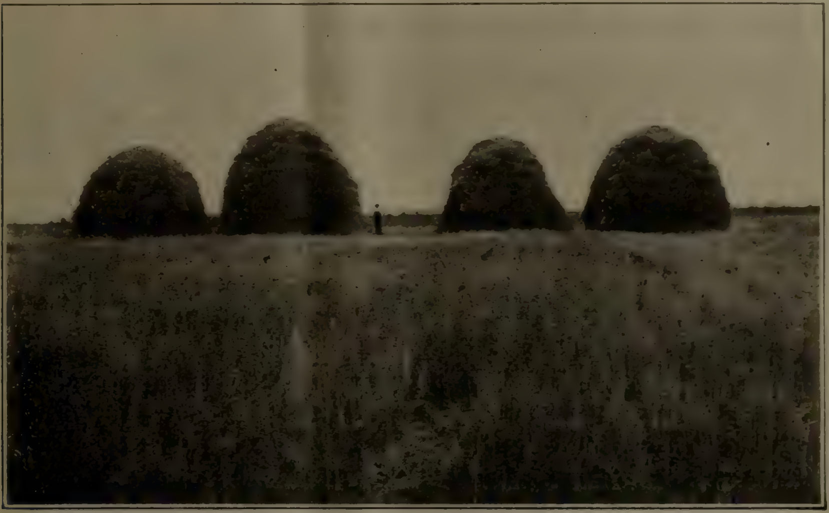

FIG. 7.—Stacks of headed wheat awaiting thrashing on a Utah dry-land farm.

With the exception of 1916, when the yield per acre was lower than usual, there has been a gradual increase in the wheat production of Utah since 1912. Most of this increase has been winter wheat. The average increase in the past five years has been about 25,000 acres annually.

The varietal experiment at Nephi shows that the soft white winter wheats are inferior in yield to the Crimean group of hard red winter wheats. Some farmers, however, have reasons other than yield which they think justify them in growing the soft white varieties. The Koffoid and Gold Coin are the leading varieties in the soft white group in Utah. These wheats were at one time the most popular varieties in the State. The hard red wheat brings a better market price than the soft white wheat, but both soft and hard wheat are needed by millers for blending purposes.

Wheat varieties in Utah are badly mixed. Often a field is a mixture of seven or eight distinct types. Some of these may be hard, others soft. Such a condition makes it difficult to obtain reasonably pure seed. Yields and profits could be increased by the elimination of inferior varieties through seed selection.

Varieties to grow.—A large number of winter-wheat varieties are being grown in Utah, but the Turkey, a hard red winter wheat from Russia, is the leading variety. In the central and northern sections of the State, in addition to Turkey, the Gold Coin and Koffoid varieties are quite extensively grown. The Gold Coin and Koffoid are beardless, brown-chaffed, white-kerneled varieties. Many farmers object to Turkey wheat because it is unpleasant to handle on account of its beards. Another objection is that the beards make the straw less suitable for feeding. This latter objection is justifiable when feed is scarce.

In a varietal experiment with winter wheat at the Nephi substation during the 9-year period from 1908 to 1916, inclusive, seven of the eight leading varieties belonged to the Crimean group of bearded, white-chaffed winter wheats with hard red kernels. The leading varieties in this experiment were the Turkey, Crimean, Bulgarian, and Kharkof. The Ghirka Winter, which ranked fifth in yield, is a beardless, white-chaffed variety with hard red kernels.

Seeding.—The best date to sow winter wheat is influenced by numerous conditions. In Utah, winter wheat should be sown early enough to allow some growth before winter. As a general rule, early seeding is practiced and recommended when soil and moisture conditions allow. Too much fall growth is not desirable, because the wheat may reach the jointing stage before winter or the spring growth may be so rank that all the available moisture is exhausted before the crop matures. On most Utah dry farms it is not possible to hold the moisture near enough to the surface to allow seeding at the desired time. Early seeding is done with the expectation that the rains will bring up the crop; otherwise, sowing is delayed until there is sufficient moisture to germinate the seed and support growth. Better stands are usually obtained from sowing after the rains. Results during the past 13 years show that the best yields have been obtained from sowing between September 15 and October 15.

Three pecks is the common rate of seeding wheat on Utah dry farms. While 3 pecks may be sufficient when moisture conditions are favorable at seeding time, experimental data indicate strongly the necessity for sowing at a heavier rate.

Eight years' results at the Nephi substation show that the best yields were obtained by sowing at the rates of 5 and 6 pecks per acre.

If the seed is sown early in dry ground, it is better to seed at this rate. Then, if some of the kernels fail to germinate and others that do germinate are crusted under, the stand will probably be about right, whereas if seeding is done at a lower rate poor stands result. Again, if seeding is done late in the fall, sow 5 or 6 pecks per acre, because many of the plants will probably winterkill and heavy seeding will insure a better stand. The best rate of seeding is dependent upon the date of seeding and the condition of the soil at seeding time. If the soil is dry or if seeding is done late in the fall, sowing 5 or 6 pecks per acre is recommended. If the time and conditions are more favorable, sow at the rate of 3 or 4 pecks per acre. Increase the rate for treated grain that has not been thoroughly dried.

The best results were obtained at Nephi by seeding from 1 to 3 inches deep. Yields decreased with increased depths of seeding. On a lighter soil, favorable results may be obtained by deeper seeding.

The best date, rate, and depth to sow winter wheat vary from year to year. They are determined largely by the kind of soil and its condition and by the climatic conditions during the fall months.

Cultivation of the growing crop.—The practice of harrowing winter wheat in the spring has been advocated quite generally in Utah. Some farmers think that it pays to harrow in the spring, while others do not. Harrowing is intended to break the surface crust, destroy weeds, and conserve moisture.

Experiments at Nephi during the past seven years show that harrowing winter wheat in the spring was not profitable. Like results were reported by the substations at Aberdeen, Idaho, and Moro, Oreg. In consideration of this evidence, harrowing winter wheat in the spring on Utah dry farms is not recommended.

SPRING WHEAT.

Only about one-fourth of the wheat grown in Utah is spring sown, and most of this is grown under irrigation. Spring wheat on the Utah dry farms is a minor crop, and in most cases it is used simply as a filler where fall wheat has winterkilled. Spring wheat is not profitable on the dry farms in comparison with winter wheat. The average yields of the leading winter wheats at Nephi are more than twice those of the leading spring wheats. In some limited sections it may be impossible to grow winter wheat because of late spring frosts. In these localities spring varieties may perhaps be substituted. Spring varieties should not be grown where winter varieties are successful.

It is more difficult to mention known and adapted varieties of spring wheat than of winter wheat, because the former are not grown extensively either commercially or in an experimental way. The Pacific Bluestem, Red Chaff, New Zealand, Sonora, Defiance, Ghirka

Spring, and Marquis are among varieties that have given the best results on the Utah dry farms. Red Chaff and Sonora have about disappeared from cultivation, while Sonora is a poor milling wheat. Kubanka is the leading spring durum wheat for Utah dry farms. At the Nephi substation the durum wheats have yielded better than the spring common varieties. However, there is no ready market for durum wheat grown in Utah. Local flour mills are not equipped to grind durum wheat and there is not enough grown to attract outside buyers. At the Nephi substation Ghirka Spring and Marquis are the leading spring common varieties.

Spring wheat should be sown as early as possible at the rate of 3 to 4 pecks per acre, to a depth of 1 to 3 inches. Durum spring wheats should be sown at the rate of 4 to 5 pecks per acre. The durum varieties do not stool as much as the common spring varieties; hence more seed should be sown.

EMMER.

In general, emmer is grown only experimentally in Utah. A few farmers, however, are growing this crop on a commercial scale for seed. Emmer is well adapted to Utah dry lands, but the crop is not generally grown, as there is no ready market for it. The winter varieties are more popular and better adapted to Utah conditions than the spring varieties. Winter emmer is hardy and drought resistant, but is not as hardy as winter wheat.

Black winter emmer is the best known and most commonly grown variety. At Nephi the 9-year average acre yield of this emmer was 37 bushels of 32 pounds each. This is a larger yield in pounds per acre than was produced by either barley or oats.

Winter emmer should be sown at the rate of 6 to 8 pecks per acre on the oat side of the drill. Sow when moisture conditions are favorable for germination, covering the seed 1 to 3 inches deep. Good fall growth is desirable. Emmer is an excellent stock food, especially for hogs and sheep.

OATS.

Most, if not all, of the oats grown on the Utah dry farms are used for feed. During the five years from 1912 to 1916 the area sown to oats in Utah increased from 91,000 acres in 1912 to 103,000 in 1916. The lowest yield during these years was 4,140,000 bushels in 1913 and the highest, 4,750,000 bushels in 1914. A considerable part of this crop was grown on irrigated land.

WINTER OATS.

Winter oats are grown to some extent on the dry farms, but as a rule this crop is uncertain because of winterkilling. The Boswell

Winter oat is the only variety that is grown commercially on Utah dry farms. The Winter Turf, however, is a promising variety.

The Boswell Winter is a local name for a black winter oat introduced into Utah from England a number of years ago by Mr. Stephen Boswell, of Nephi. Its black hull lowers its market value but does not affect its feeding value. The 8-year average yield of Boswell Winter oats at Nephi was 22.5 bushels per acre, but during this period the annual yields ranged from a total failure to 57 bushels per acre. The best variety of spring oats in the same years averaged 20.2 bushels.

Eperimental results at the Nephi substation show that winter oats yielded best when sown between October 1 and 15 at the rate of 7 or 8 pecks per acre and to a depth of 1 to 3 inches.

SPRING OATS.

Spring oats are not commonly grown on Utah dry farms. Varietal experiments at the Nephi substation show that if they are grown the midseason varieties yield best. The Swedish Select, Black American, and Big Four yielded better than Sixty-Day or Kherson, the latter being early varieties. Spring oats should be sown as early as the soil can be put in condition for sowing. Sow at the rate of 5 to 6 pecks per acre and cover the seed about 2 inches deep.

BARLEY.

Barley is not grown extensively on the Utah dry lands. Winter varieties are not hardy enough to be grown without considerable danger from winterkilling, and spring varieties are not adapted to Utah conditions. It is grown mostly for feeding, though some of that grown under irrigation is marketed.

The acreage devoted to barley in Utah is small when compared with that of either wheat or oats. In 1912 barley was grown on 25,000 acres, which produced 1,125,000 bushels. The acreage had increased to 34,000 in 1916, and the production to 1,224,000 bushels. The production in 1915 was 1,445,000 bushels.

WINTER BARLEY.

Winter barley is not commonly grown on Utah dry lands. At elevations above 4,000 feet winter barley is likely to winterkill. It is better adapted to the lower elevations than spring barley. When winter barley survives with a good stand it always yields higher than the spring varieties. Winter barley matures earlier, grows taller, and is more easily handled than spring barley.

At the Nephi substation the 8-year average yield of White Club winter barley was 23.3 bushels and that of Tennessee Winter was 21 bushels. This is about one-half more in pounds of grain than was produced by winter oats. Better yields of these barleys should be obtained at lower elevations than that at Nephi.

Winter barley should be sown at the rate of 7 to 8 pecks per acre. Where winterkilling is severe, the rate of seeding should be increased. Sow when moisture conditions are favorable for quick germination. A good growth before winter begins is advantageous and increases the chances for a good crop. Sow from 1 to 3 inches deep for the best results. The seed-bed preparation should be the same as for winter wheat.

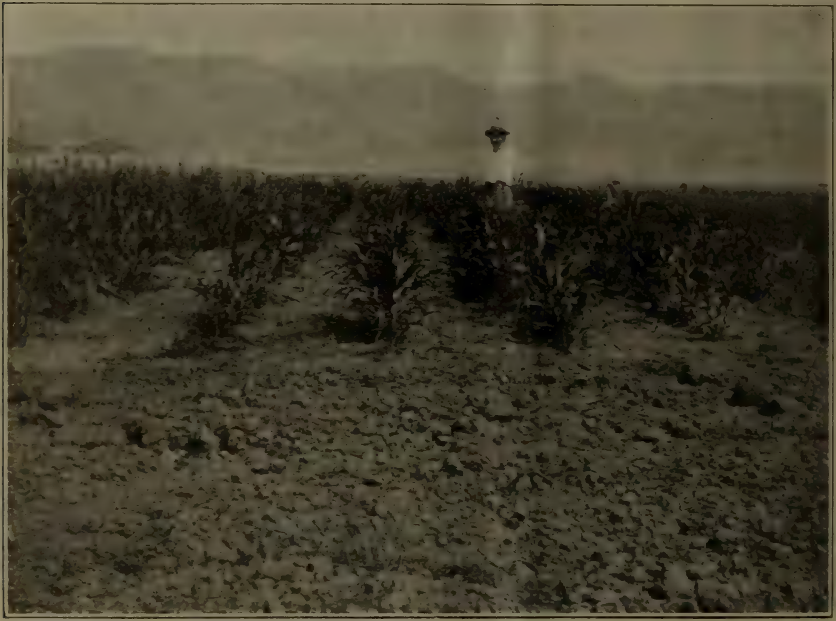

FIG. 8.—A Utah dry-farm cornfield. The cool nights at the high altitudes of these mountain valleys are not favorable for the growth of corn, as is evident from the dwarfing of this crop.

SPRING BARLEY.

Spring barley is not a profitable cash crop on Utah dry lands. Only the early-maturing varieties should be grown. The Coast, Mariout, and White Smyrna are the leading dry-land varieties in the intermountain sections. Spring barley is difficult to handle on the dry lands because of the short growth.

MINOR GRAIN CROPS.

CORN.

Corn is not extensively grown in Utah on the dry lands. If it were possible to grow corn profitably on the dry farms, the cropping system would undoubtedly change from wheat and fallow to wheat and corn. Flint varieties do better on these dry lands than dent varieties. The Jumbo and White Australian are the most commonly grown varieties. Profitable yields are obtained on some of the dry-farmed soils in limited sections, but corn is not generally a profitable dry-land grain crop in Utah. The cool nights in the mountain valleys are unfavorable for growth and cause the dwarfing shown in figure 8.

Corn should not be planted until the danger from spring frost is past. Plant shallow on heavy soils and deeper on the lighter soils. Keep the cornland free from weeds. A thin stand is preferable.

GRAIN SORGHUMS.

Grain sorghums are not commonly grown on Utah dry farms. In the southern part of the State and on the light soils sorghums are grown with varying degrees of success. These crops, however, are not commercially grown in Utah. Dwarf milo, white kafir, and brown kaoliang are the most promising grain sorghums. Sorghums should not be seeded until late in the spring when the ground is warm and growth will not be checked by cool weather. They should be sown in rows and cultivated the same as corn.

PROSO.

Proso millets are not adapted to Utah conditions. All experimental data show that this crop can not be profitably grown on these dry lands.

FLAX.

Experimental results with flax have not been promising. It is doubtful whether flax is of much value on the dry lands, but at the lower altitudes and under irrigation it should be a very profitable crop. Flax should be sown about corn-planting time at the rate of 15 to 20 pounds per acre. Sow shallow and on clean ground.

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SAVING VEGETABLE SEEDS FOR THE HOME AND MARKET GARDEN

W. W. TRACY, Sr.
Superintendent of Testing Gardens, Horticultural
and Pomological Investigations

SUPERSEDED BY 1390

FARMERS' BULLETIN 884

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. September, 1917

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1917

WITH the present urgent necessity for producing increased quantities of food, the seed supply becomes very important.

Where the seed itself is used for food the high prices have tended to throw much-needed seed stocks into the food market, and in many other cases increased plantings have drawn heavily on stocks already low on account of the cutting off of European sources of supply.

As an emergency measure, therefore, it is important that as much seed as possible should be saved on our farms and in our market gardens. It has been done widely in the past and can be done readily again.

This bulletin aims to give plain and explicit directions for saving the seed of our garden vegetables.

SAVING VEGETABLE SEEDS FOR THE HOME AND MARKET GARDEN.

CONTENTS.

	Page.
Present shortage of vegetable seeds	3
How the supply may be increased	3
Plants which bear seed the year they are planted (annuals)	4
Vegetables the seeds of which are eaten	5
Vegetables the fruits of which are eaten	6
Annuals the stems or leaves of which are eaten	7
Annuals the roots of which are eaten	8
Plants which require a winter rest before producing seed (biennials)	9
Biennials the stems or leaves of which are eaten	9
Biennials the roots of which are eaten	13
Labeling, fumigating, and storing vegetable seeds	15

PRESENT SHORTAGE OF VEGETABLE SEEDS.

THE disturbing effect of the world war has been very great on the normal course of the seedsmen's business. In few enterprises had the civilized nations been bound into a more compact unit than in the growing and handling of seeds. Each slight variation of climate and social condition had been taken into account in an attempt to locate the regions where the various seeds should be grown. Each of the many species of plants grown in our gardens became a separate problem, and in many cases varietal characteristics were considered in determining the place and manner of handling the crop. The necessity for readjustment and relocation of growing sources has been largely met, but in addition to these difficulties the seedsmen have had to supply for the current year a very much increased demand. This arose from the greatly enlarged plantings of those regularly engaged in truck growing and market gardening and from the stimulated plantings made by city and village residents under the home-garden and vacant-lot campaign of the last spring. It seems desirable that, where feasible, home and market gardeners should prepare to meet their own seed requirements for next spring's planting.

HOW THE SUPPLY MAY BE INCREASED.

In earlier times the home saving of seeds was the rule. Many garden varieties are labeled with place names, which usually indicates that they have been developed by community selection at the localities whose names they bear. As late as the middle of the last century many individual market gardeners in this country jealously guarded the seed of certain varieties and strains which represented years of intelligent selection in their hands. A few such superlative varieties are yet to be found in the possession of gardeners near the old market-gardening centers. In the past also the village and farm gardener saved his own seed of the few varieties of vegetables he grew. This custom has practically ceased, but here and there are farmers and villagers who cling to "family" varieties of certain vegetables. Long-standing local types are probably most common in the Appalachian Mountain region. European gardeners have retained local or family varieties much more tenaciously than Americans.

That there are advantages in thus saving seed where it is grown is generally recognized. This widespread opinion is also held by seedsmen, since the enthusiastic description of a novelty frequently includes a history of its having been secured with great difficulty from a skillful grower in whose possession it had remained for many years or even for generations. These advantages are twofold: (1) The selection which the gardner gives his seed plants, while not greater than that which the seed grower gives his seed stock, is often better than can be given to the seed that is placed on the market; and (2), the plants selected will be the ones which succeed best under the local environment.

The following instructions are directed to methods of seed saving rather than of seed selection, as few persons engaged in any branch of gardening have the insight, patience, perseverance, and enthusiasm required for the development of valuable new varieties of vegetables. Truckers require seed of their specialties in such quantities that it is rarely practicable for them to grow their own supply. It is possible, however, for home and market gardeners to relieve part of the strain on our depleted stocks.

Two varieties of the same vegetable will often cross if seeded together in the same garden. Weather or other conditions sometimes cause a short crop of seed or a failure. Fortunately, well-matured seeds, if properly stored, with the possible exception of those of the parsnip and onion, should retain their vitality for 5 to 10 years. It is thus possible to tide over poor years and to grow all the seed needed for a small garden, even to the extent of handling two or more varieties of one vegetable.

PLANTS WHICH BEAR SEED THE YEAR THEY ARE PLANTED (ANNUALS).

A large number of garden plants are annuals, including, of necessity, all those of which the seed or the fruit is the part eaten. Only a few of those vegetables of which some part of the growing plant is used for food are annuals.

VEGETABLES THE SEEDS OF WHICH ARE EATEN.

Very little care is required to save seed for a home supply of the crops of which the seeds are eaten, since the seed is well advanced toward maturity when usable. Selection is important in this group, however, especially to insure healthy seed. Any surplus dried seed of these plants may be used for food.

BEANS AND PEAS.

The best seed of beans and peas is to be obtained by marking a few of the finest plants with a bit of cloth at the beginning of the harvesting season and allowing the crop of these plants to ripen completely. In making such selections it is best to choose plants alike in varietal character and earliness. When ripened until dry, pull these plants in the early morning, in order to avoid shattering, and hang or spread them in an airy, dry place until the seed is quite hard. Then shell the seed, spread it out not over two or three grains deep, and when thoroughly dry store it for the winter in bags of coarse open-meshed fabric hung in a cool, dry place.

Pods which for any reason have been overlooked when picking beans or peas for the table should be saved, since they can be shelled for seed, though inferior to the selected stock described above. In saving seed from remnant crops of this kind it is well to discard all pods containing only one or two seeds, as these may have come from plants with a tendency to produce poorly filled pods.

Some very destructive bean diseases, including pod-spot, are carried in the seed; so it is extremely important to observe the general rule that no seed should be saved from diseased plants when saving beans for seed. Never save seed from pods which are not bright and clean.

SWEET CORN.

The best seed corn can be secured by allowing it to ripen on the plant, and, since a single ear will be seed enough for a small garden, it is quite practicable to do this. Select the best and earliest ears by stripping down the husks to examine the grain and to remove any worms that may be found, and then carefully fold them back and hold them in place by an elastic band or a string. Allow these ears to ripen thoroughly on the stalk. In the North it is often better to pull and hang the plant where there will be no danger from moisture, frost, or even chilling until the seed is thoroughly dry. All the ripe ears remaining at the end of the season in any crop of sweet corn should be harvested and saved. The best ears will make passably good seed, and everyone whose early life was spent on a farm remembers the enjoyment that was to be found in parched sweet corn.

Sweet corn spoils much more quickly than field corn, and can not readily be cured in large shocks, but should be husked from the stalk and spread thinly on staging to cure. A convenient way of storing sweet corn is on the ear.

VEGETABLES THE FRUITS OF WHICH ARE EATEN.

A fruit, which is developed from a blossom, consists of the seed and its inclosing parts. It is not necessarily fleshy, though that is the popular conception of the term. It is a very simple matter to save seeds of these vegetable fruits. They are in large part allowed to ripen before being brought to the table, and thus there is only the additional trouble of cleaning the seeds, which otherwise would be discarded.

CUCUMBERS AND SUMMER SQUASHES.

Cucumbers and summer squashes are used commonly long before they are ripe, or even before they have reached their full size, the one for pickles or for salad, the other as a vegetable. In saving seeds, select and mark fruits of desirable character while in the usable stage and allow them to remain on the vines until fully ripe, which will be indicated by a change of color, or by this change and a hardening of the surface. Split the ripe fruits, scrape out the seed and pulp, and wash them until clean, pouring off the refuse and light, floating seeds. Seedsmen when handling large quantities ferment the mass of seed and pulp from these and other fleshy fruits, but most home gardeners will find it simpler to clean the seed immediately in one operation. Then, spread the washed seed not over two grains deep and place it in the bright sunshine to dry. Stir the seed frequently while drying, but do not subject it to frost or even a severe chill. Any quantity less than a quart of seed should be ready for storing after one day's drying. If a large quantity of seed is being saved, it is important not to bulk it until thoroughly dry, as it heats readily. This will take from two to five days.

WINTER SQUASHES, MUSKMELONS, AND WATERMELONS.

The fruits in this group are not used until ripe. Seed saving consists of picking satisfactory fruits of high quality and in washing the seed with water until clean; then spreading, stirring until dry, and storing.

TOMATOES.

The character of the tomato plant is of great importance. Select one or more plants which bear a high proportion of good fruits, taking into account size, smoothness, solidity, and freedom from cracking in the fruit, and vigor, productiveness, and freedom from disease in the plant. Tag the fruits on these selected plants and allow them to ripen on the plant until past their edible condition, but do not permit them to decay. Crush the fruits and separate the skins and denser portions of the flesh by hand or with a coarse sieve, fold the seeds with the softer pulp into a square of coarse muslin or strong cheesecloth, and work this energetically with the fingers under water. It is thus possible to clean the seeds very nicely by forcing the pulp out through the cloth. When clean, spread the seed thinly in an airy place until dry and then store it.

If seed is to be saved in as large a quantity as one-half pound or more it will pay to allow the crushed fruit to ferment for about four days in a cask or bucket, with frequent stirring of the mass. The seeds will settle to the bottom and the pulp will rise to the surface, from which it can be poured. The seed should be washed with pure water until clean, spread out thinly, stirred frequently until dry, and then bagged.

EGGPLANT.

For the home garden, seeds of the eggplant in sufficient number can be picked from ripe fruit with a penknife and dried and stored.

PEPPERS.

Select well-ripened fruits of peppers, spread the seed thinly until very dry, and then store it.

OKRA.

Okra seed for a small garden can be secured best by selecting one or more plants for seed, picking the early pods until the plant is growing vigorously, and then allowing it to set and mature a full crop of pods. The varieties having angular pods will split open and the seed will be lost unless the ripe pods are harvested immediately. The round or velvet podded varieties may be left on the plant until all are ripe, since they do not split open. The seeds after removal from the pods are to be dried and stored.

ANNUALS THE STEMS OR LEAVES OF WHICH ARE EATEN.

Only two stem-and-leaf vegetables can be grown for seed the first year with any certainty of success.

LETTUCE.

Lettuce is an annual crop, and if the seed is planted early enough so that the setting and ripening do not occur during the greatest heat of summer all varieties may be seeded. The safest practice is to start the plants intended for seed in hotbeds or coldframes and then transplant to the garden. As the plants reach edible maturity select a few of the most satisfactory ones for seed, cut out any crowding plants, give the soil a shallow cultivation, and if very dry, water the plants. As the seeding plants develop it may be necessary with

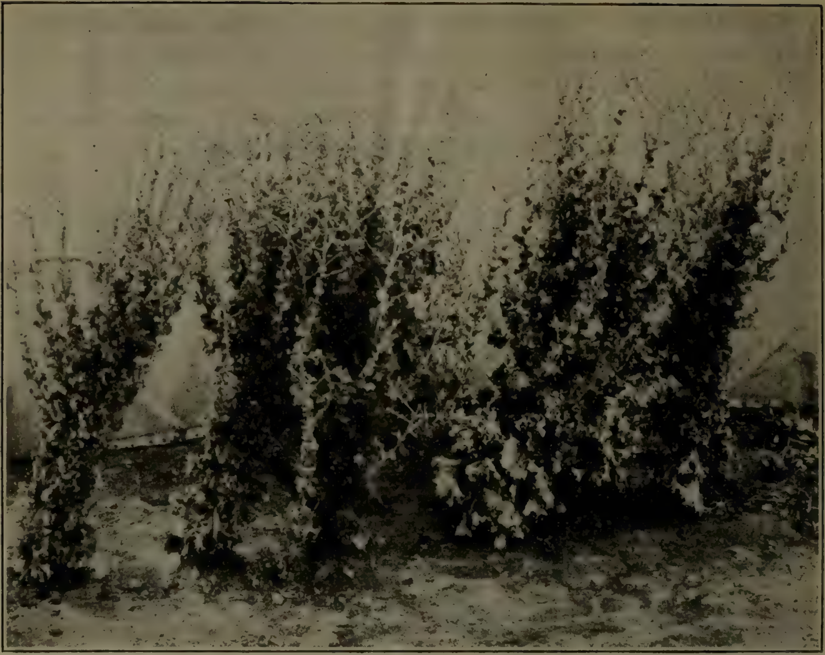

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FIG. 1.—Seeding plants of lettuce. These will soon be ready for harvest.

some of the harder heading sorts to cut or pull the head leaves apart carefully in order to allow the seed stalk to push through.

The seed crop matures slowly, and when the first seed heads open so that there is danger of serious loss from shattering, pull the plants (fig. 1) and put them, roots up, in a paper bag, hanging it in a dry, airy place until the seed is fully ripened. Then thrash it, clean it of bits of stem and dirt by sifting and winnowing, and store in a dry place.

MUSTARD.

Mustard seed can readily be grown from a crop sown in very early spring. When the pods have turned yellowish, cut the seed stalks in the early morning and spread them on paper or cloth under shelter. When the pods are quite dry, beat out the seed and spread it thinly for a week or 10 days, as it heats readily if in large bulk

ANNUALS THE ROOTS OF WHICH ARE EATEN.

Only one root vegetable falls into this group.

EARLY RADISHES.

Most varieties of early radish planted in the spring as soon as the ground can be worked will produce seed. In such crops some plants will shoot to seed quickly, but they are apt to be the poorest stock and the seed of these can not be depended upon to give good roots. It is better, therefore, to select carefully some of the finest roots and to cut off most of the top, leaving a few small central leaves. Lay the plants in a moist, airy place for a few hours, or over night, to harden, and carefully set them out with the crown about an inch below the surface. Usually most of them will start into growth and mature a crop of seed. When this ripens, cut the plants and lay them on a sheet exposed to the sun. The seed will harden quickly, and can then be beaten out, thoroughly dried, and stored.

PLANTS WHICH REQUIRE A WINTER REST BEFORE PRODUCING SEED (BIENNIALS).

The biennials include nearly all the vegetables of which we use the growing parts, such as stems, leaves, or roots. One must plan beforehand in growing seed of these, since they must be carried over winter and usually require protection.

BIENNIALS THE STEMS OR LEAVES OF WHICH ARE EATEN.

SPINACH.

Spinach may occasionally be grown for seed as an annual, but to be successful it must be planted very early. The crop which has been wintered over is much better for seed growing. With the protection of a light covering of straw it may be planted in the autumn and wintered over in all parts of the United States. This protection is not necessary south of the latitude of Philadelphia.

As spinach plants come into flower and fruit they may be seen to differ materially; one, which is usually the first to bloom, will produce on tall stems an abundance of pollen, which is easily blown about by the wind, but no seed; the other will produce no pollen, but at each leaf on the upper part of the stem will appear round or more or less prickly fruits, which if the plant stands near one of the first kind will develop seed. Both sorts of plants grown near each other are essential to the production of seed. The seed matures slowly and unevenly and is best saved by pulling the plants and putting them in a paper bag, which should be hung in a protected place until the seed is ripe and dry, when it can be thrashed off, winnowed, and stored.

ENDIVE.

To grow seed of the endive it is necessary to plant the crop in the late fall (September in the latitude of Philadelphia), winter over the plants in coldframes, and grow to seeding in the spring. The plants bloom through a long season and should be pulled and hung up to dry when most of the heads are ripe. They are difficult to thrash, but the plant after drying can be placed in a stout bag and beaten until the seeds are released. These must then be sifted, winnowed, and stored.

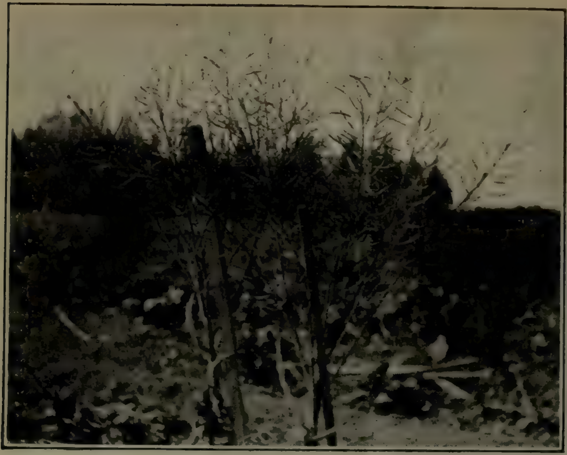

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FIG. 2.—Seeding plants of cabbage. Note that two plants are set together for cross-pollination and that the seed stems are staked.

KALE, COLLARDS, CABBAGE, AND KOHL-RABI.

All the plants in this group require the same care in harvesting and curing the seeds. As they shatter from the seed pods very readily, it is best to cut the seed stalks when the pods have turned yellow. Early morning, when the plants are moist with dew, is the best time to harvest. Spread the seed in a dry, airy place on sheets of paper or cloth to ripen and cure. When the seed is quite hard, beat it out, and spread it in a thin layer for further curing. All these precautions are necessary, because these seeds heat very quickly if not entirely ripe and dry. They will hybridize freely among themselves, so that one should not attempt to grow more than one crop of this group in the same garden at the same time.

Kale and collards are very hardy, and may be left out all winter, with slight protection in the North. They will send up blossom stems early in the spring and mature a crop of seed.

Kohl-rabi should be planted in midsummer, so as to make good-sized "bulbs" for storing in trenches or coldframes. They are set for seed in early spring.

Seed of cabbage in large quantities is grown in many different ways. In some places the stumps from which matured heads have been cut are successfully set for seeding. In Denmark the head and a bit of the stem are cut off and wintered in shallow trenches. In early spring they throw out roots like a giant cutting, start into growth, and produce a good crop of seed. On Long Island, plants are set so late in the season that they do not develop marketable heads before the ground closes up in the fall, but the plants are stored in trenches, given a little protection, and, when set in the spring, will produce a crop of seed. It is possible to grow seed from any part of the cabbage plant that includes a bit of the stem that has wintered so as to be in green and healthy condition. It is generally necessary, however, in order to secure a good yield, to set out two or more plants (fig. 2), as a single plant rarely produces seed.

Plants for seeding should be set as early in spring as practicable and protected from frost, especially if they have been blanched in storing.

CELERY.

Celery is not grown extensively enough in home gardens to make home seed saving an important consideration. Plants which have been stored for winter, if carried over and planted early in the spring will flower and ripen seed in early summer. The seed is borne in flat-topped clusters and does not ripen all at once. When the larger clusters are ripe the plant should be pulled and hung in a dry, shady place with good ventilation. As soon as the seed is well ripened, beat it off, clean, and store it.

ONIONS.

The edible part of the onion is composed of the swollen bases of the leaves, which accounts for onions being placed here rather than with root crops. Seed is not produced until the second season, after the bulbs have had a period of rest, but it is essential to the production of good seed that the seed-bearing bulbs should be well rooted. Often bulbs which have failed to make vigorous root growth will develop blossom heads and seem to set seed, which, however, will be found to have very little vitality. One will be most likely to succeed by selecting well-matured bulbs late in the autumn, setting them so that the crowns are about 3 inches below the surface, and then gradually at the approach of cold weather ridging the earth over them to prevent their freezing. Early in spring, remove the ridges gradually; and as the seed stalks develop, support them by stakes. (Fig. 3.) As the seed pods open

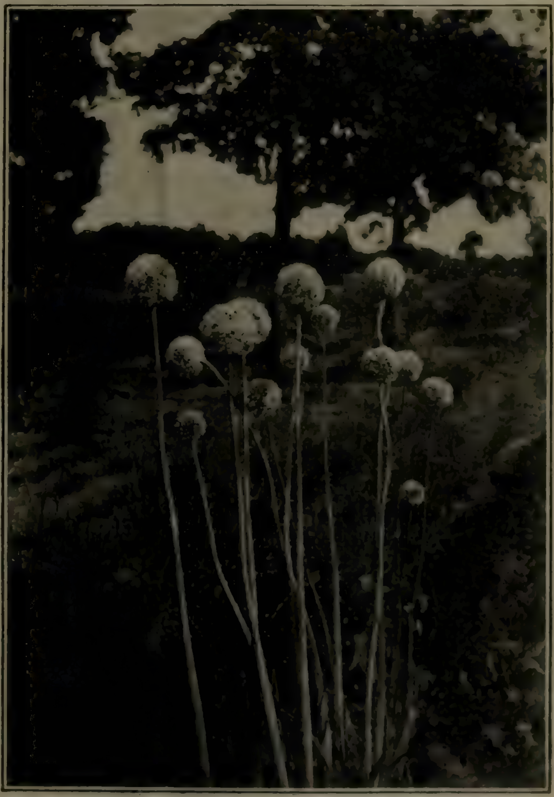
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FIG. 3.—Seedling plants of onion in a home garden. They are in blossom and should be staked.

and the seed turns black before it is ripe, care should be taken not to gather the heads until most of the seed is really ripe, but before it begins to shatter. Cut the seed stalks with about a foot of stem and spread them not more than one head deep in trays lined with paper, in order to save the seed which falls out. Expose these trays to the sun and air until the seed is entirely dry; then rub it out, winnow, and store it.

There are a number of kinds of onions that rarely produce seeds, but are increased by sets or bulblets which grow in the blossom heads, often entirely replacing the blossoms. One group of these, called winter-top, asparagus, or perennial onion, does not make large bulbs, but is extremely hardy. The top sets of these may be planted anywhere in the United States during September and will give a good crop of early spring onions. These sets are easily stored from the time of ripening in midsummer until planting time in the autumn, and no gardener need purchase sets after once getting a stock.

Another group, called spring-top or red-top onions, is not quite so hardy, but the top sets of these will make good-sized dry bulbs for storing. They should be planted as early as possible in the spring. The sets when ripe may be stored in a cool attic or second-story room.

There is yet another type of these onions, called potato or multiplier onions, which does not make either top sets or seed. The bulbs of these split up into a number of bulblets, each of which, if planted in September, will produce large, dry bulbs for winter use the following year. The large onions planted at the same time produce sets. This group is hardy as far north as central Pennsylvania and may be planted in early spring north of that latitude, producing heavy crops in highly enriched soil.

Shallots are similar to the potato onions just described, but they never grow into large bulbs. The two types are frequently confused, and sets of shallots are sometimes sold for potato onions.

POTATOES.

Irish potatoes are tubers or swollen stems, and so are grouped here rather than with root crops. For the quantities used in the home garden it is, in general, better for the gardener to rely on his local dealer for a supply of northern-grown seed tubers. If he is located in the North, however, he can successfully save his own seed potatoes. These can be stored in a cold but frost-free cellar if available, but are very satisfactorily kept in an outdoor pit.

For further information in regard to Irish potatoes, see Farmers' Bulletin 533, "Good Seed Potatoes and How to Produce Them," and Farmers' Bulletin 847, "Potato Storage and Storage Houses."

BIENNIALS THE ROOTS OF WHICH ARE EATEN.

This group comprises all of the root vegetables except early radishes. The part used is the swollen root in which the plant has stored a supply of nourishment for use in the spring to push up its seed stalk in the shortest possible time. It is thus necessary to make seed growing a separate process from crop production.

PARSNIPS AND SALSIFY.

Parsnips and salsify are hardy, and the roots may be safely left in place through the winter. As early in the spring as they can be handled and before they start into growth, the roots should be dug, carefully sorted, and the selected ones immediately reset from 3 to 5 feet apart. They will start into growth at once, and generally will produce a good crop of seed. The parsnip can be safely left in place until the seed crop is fully ripe, when it can be cut and stored under shelter till dry. The heads of salsify open out as they ripen, and unless gathered the seed will be blown away. It is necessary, therefore, to gather the opening heads about noon of every sunny day and spread them in an airy place until dry, when the seed can be rubbed out, winnowed, and stored.

BEETS, CARROTS, TURNIPS, AND LATE RADISHES.

The roots of the plants in this group must be stored over winter in some way, as they will not endure freezing. Seed can rarely be grown satisfactorily from the large hard roots taken from the spring plantings and can seldom be grown profitably in the home garden. When it is attempted, it is best to make special plantings in midsummer, taking pains to protect the plants from early frost and to pull and store them before severely cold weather. For seeding, select roots of a uniform, desirable character, remove the tops without injuring the central bud, cure by exposing them in the shade for a few days, and bury them. Cover lightly at first, but to an increasing depth as necessary to prevent their freezing. Set reselected roots as early as the ground can be worked, carefully protecting them from frost. As the seed stalks grow, support them by stakes.

Turnips must be harvested as soon as the pods turn yellow, being cut in the early morning to avoid shattering and laid on papers in a protected place. When the seed is ripe, it is readily beaten out, when it is to be winnowed, spread thinly for further curing, and stored when dry.

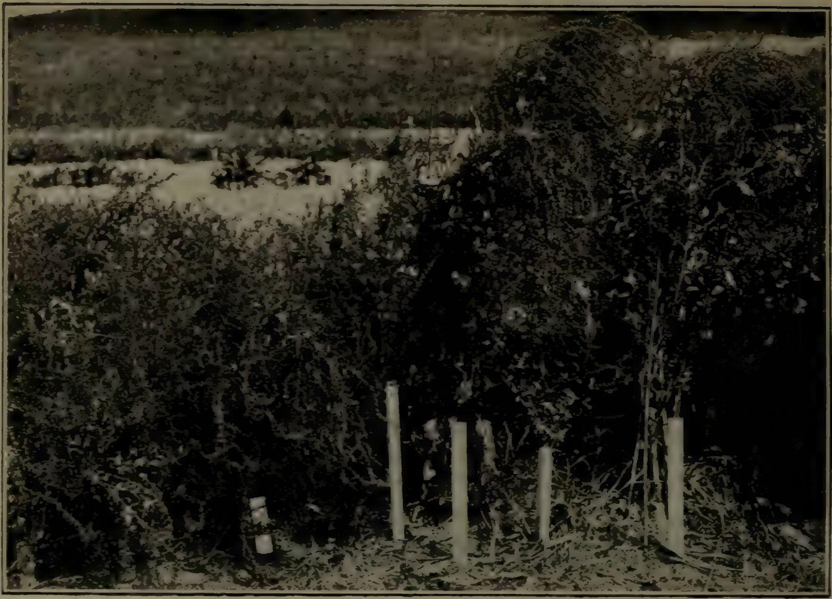

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FIG. 4.—Seeding plants of beet, planted on the scale required for a home garden. Note that there is more than one plant and that the stalks are staked.

Beets (figs. 4 and 5), carrots, and late radishes may have the seed left on the plant until ripe, when the stems should be cut and dried under shelter. The problem of thrashing and cleaning these three kinds of seed is more difficult than with most seeds. The pods of radish and the seed-bearing branches of the beet and the carrot may be placed in a strong cloth bag and beaten or rubbed until the seed can be successfully winnowed and cleaned for storing.

It is very necessary to plant at least two roots of beets, turnips, or radish and the seed-bearing branches of the beet and the carrot may will hybridize with the wild carrots so common as a weed in parts of this country, thus lowering the quality of the crop.

LABELING, FUMIGATING, AND STORING VEGETABLE SEEDS.

Seeds which have been grown and carefully saved should be well labeled and stored or all the previous labor goes for nothing. Cloth bags are the best containers for large seeds, such as peas, beans, and corn. They should be used also for larger quantities of small seeds, but for smaller lots, paper envelopes, made at home or purchased, are most desirable. Ordinary letter envelopes are fairly satisfactory, but usually are not gummed so as to close completely, and if handled carelessly small seeds may sift out of them.

Correct labeling is of paramount importance. Every envelope or container should show the kind and variety of seed, the date, including month and year when harvested, and the place where grown. For the cloth bags, a slip of paper bearing all this information should be inserted with the seed. It is very convenient also to have a tag on the outside of the bag, but on no account should the inner label be omitted, because of the liability of loss of the outside tag.

Many seeds, especially beans, corn, and lettuce, are subject to injury by a number of insects, all of which may be destroyed by fumigation with carbon disulphid. Carbon disulphid is a liquid that can be purchased in tin cans at any drug store. When poured into a dish it evaporates rapidly, producing a foul-smelling gas that is heavier than air. Therefore, in fumigating seeds, to kill insects attacking them it is necessary to place the carbon disulphid on top of the seeds in order that the gas may sink into them and reach every part of the container. A tight tin pail, box, or barrel makes an excellent container for fumigating seeds. For a tight barrel full of seeds one-half cupful of carbon disulphid is sufficient. For smaller containers, use in proportion.

Seeds to be fumigated must be dry, and if they are in paper bags, the bags should be opened. The gas penetrates cloth bags easily. The liquid may be placed in any shallow dish, such as a saucer or plate, or merely poured on the seeds. The liquid will not injure the seeds if poured directly upon them. Immediately after starting the fumigation, the container should be covered with several thicknesses of heavy paper, or other tight cover, and allowed to remain covered from one to two days. A longer fumigation in tin pails is apt to injure the germinating power of the seeds.

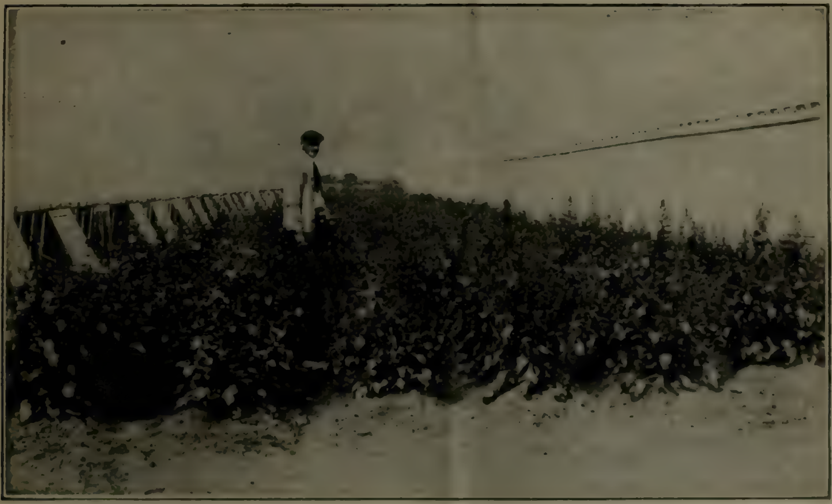
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FIG. 5.—Seeding beets grown on a scale suitable for a market garden.

Carbon disulphid gas is highly inflammable. No lights, or fire of any sort, should be allowed near while fumigation is in progress, or an explosion may occur. The foul odor of the gas disappears after the seeds have been aired for several days.

After the seed has been properly labeled, and fumigated if required, it is necessary to store in a dry, well-ventilated room. Cellars are too moist, attics usually are too hot, but a second-story room furnishes the ideal location. Seed can be protected against mice by storing in tin boxes or mouse-proof wooden boxes, or by suspending in cloth bags.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 885

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WHEAT GROWING
IN THE
SOUTHEASTERN STATES

THE FARMERS in the six Southeastern States—Tennessee, North Carolina, Mississippi, Alabama, Georgia, and South Carolina—may diversify their crops and provide home-grown bread by growing wheat on land suitable for the crop.

Wheat will furnish much pasture for stock in the fall and winter and may be used as a hay crop.

The sandy loam, silt loam, loam, and many of the clay soils when well drained and fertile are suited to wheat production. The lighter sandy soils, especially in the coastal plain, are better adapted for rye.

It is necessary to apply fertilizers to most of the southern soils, phosphorus being the principal element needed. Lime is also generally necessary for the best results.

Wheat should be grown only in rotation including legumes and cultivated crops.

Make the seed bed a fit place for the seed.

Fan and grade all seed before sowing, to remove trash and weed seeds, and treat with copper carbonate when the seed is infected with smut.

Soft red winter wheats are best, considered from all standpoints.

Home-grown seed should be used when it can be secured.

Late sowing is the most practicable and effective method of controlling the Hessian fly, but good farm practice is necessary for the best results when wheat is sown late.

Washington, D. C.

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WHEAT GROWING IN THE SOUTHEASTERN STATES

By Clyde E. Leighty, formerly *Principal Agronomist, Division of Cereal Crops and Diseases, Bureau of Plant Industry*[1]

CONTENTS

	Page
The wheat area	1
Acreage and yield	1
Soils adapted to wheat	1
Fertilizers	2
Rotations	3
Preparation of the seed bed	3
Preparing and sowing the seed	4
Preparation of seed for sowing	4
Method of sowing	5
Time of sowing	6
Rate of sowing	6
Varieties	7
Pests of the wheat crop	7
Insects	7
Diseases	9
Weeds	11
Uses of the wheat crop	12
Wheat as a nurse and cover crop	12
Pasturing and mowing	12
Wheat as a pasture and hay crop	12
Harvesting the crop	12
Manner of cutting	12
Time of cutting	13
Shocking	13
Stacking and storing	13
Threshing	14

THE WHEAT AREA

THE growing of bread grains in the six Southeastern States—Tennessee, North Carolina, Mississippi, Alabama, Georgia, and South Carolina—should be encouraged, as it leads to crop diversification and provides home-grown bread. Florida is not included, because wheat is not adapted to that State and is not successfully grown in it.

In connection with the production of bread grains in this section attention must be given to the milling facilities. Local mills must be available or it will be necessary to ship out the grain raised and ship in the flour.

ACREAGE AND YIELD

The average annual acreages of wheat harvested in these six States in the 10-year period 1920–1929 were as follows: Tennessee, 426,000; North Carolina, 507,000; Mississippi, 5,700; Alabama, 11,000; Georgia, 122,000; South Carolina, 9,000.

The average yields per acre in bushels for the same years were as follows: Tennessee, 10.5; North Carolina, 11; Mississippi, 15.6; Alabama, 10.6; Georgia, 10.3; South Carolina, 11.4.

SOILS ADAPTED TO WHEAT

Wheat does best on well-drained loam, silt loam, and some of the clay soils. Light, sandy soils and heavy, poorly drained clay soils are not desirable for wheat. Since there is so much sandy land in the coastal plain, wheat is not a crop that can be generally grown there. On the heavier types of sandy loam soils in the coastal plain, however, good wheat yields can be obtained. Rye is a better crop than wheat on the light, sandy lands. The Piedmont and mountainous sections of the Southeastern States contain much good wheatland.

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Wheat should not be sown on land the drainage of which is poor. If the land is subject to overflow or if water stands on it after rains, wheat should not be sown, for the plants will not live and thrive on such land. Low places in fields can often be drained sufficiently to prevent injury from standing water by opening furrows in the direction of the natural slope. An excessive amount of water in the soil is liable to result in winterkilling. A soil to be good for wheat should contain plenty of vegetable matter and plant food and should not be acid.

FERTILIZERS

For soils that are not in a good state of fertility for wheat the following application of fertilizer per acre, applied when the grain is sown, will be generally profitable:

Superphosphate (acid phosphate), 250 pounds; potash salts, 25 to 50 pounds; nitrate of soda, 25 pounds; applied when the seed is sown.

Nitrate of soda, 75 to 100 pounds; applied after growth starts in the spring, generally early in March.

In place of these applications a 3–10–3 fertilizer—that is, one containing 3 per cent of nitrogen, 10 per cent of phosphorus, and 3 per cent of potassium—may be used. Of this, 150 to 250 pounds per acre on the richer lands and 250 to 350 pounds on the poorer lands may be applied when the wheat is sown. If some other formula of about the same composition is more readily obtainable, it may be used. The principal requirement is a large amount of phosphorus and smaller amounts of the other elements.

Most of the southern soils are acid and are benefited by an application of lime either as slaked lime or as ground limestone. Lime can be applied through the grain drill or lime spreader, preferably several weeks before the seed is sown. It may also be scattered over the plowed land with a shovel and harrowed in. There are some waxy limestone soils in central Alabama and northeastern Mississippi, and limestone valleys in several States, which without lime are suitable for wheat if sufficient vegetable matter is incorporated in them. Nitrogen usually can be added most cheaply by growing legumes, such as velvetbeans, cowpeas, soybeans, the clovers, hairy vetch, and Austrian field peas. Phosphorus is generally deficient in southern soils and must be added as superphosphate, steamed bone, etc., or in a complete fertilizer.

The best fertilizer to build up the land in preparation for wheat is 5 or 6 tons per acre of barnyard manure, to each ton of which 40 to 50 pounds of superphosphate or rock phosphate (floats) is added before spreading. It is advisable to apply the manure to a preceding cultivated crop, such as potatoes or corn; otherwise a heavy growth of straw and consequent lodging may result. If green manure, such as cowpeas or clover, is plowed under, 200 to 250 pounds of superphosphate should be added per acre.

ROTATIONS

Wheat should be grown only in a rotation including legumes and cultivated crops. Local conditions should determine the rotation and the particular crop to be used. Wherever possible, wheat should follow some legume crop, such as cowpeas or soybeans, as better yields are obtained after these crops than after corn.

In the southern part of the Cotton Belt, where the boll weevil is a serious pest, the following rotation is giving good results:

First year: Cotton. The cotton stalks plowed under early and wheat sown.

Second year: Wheat, followed by cowpeas or soybeans to be cut for hay.

Third year: Corn and velvetbeans. Beans and cornstalks pastured and turned under in early spring for cotton.

Good farm practice under boll-weevil conditions requires that the cotton stalks be plowed under as soon as the bolls are all open and picked, care being taken to cover the stalks completely in order to destroy the insects. The land should not be harrowed but should be gone over with a roller and the wheat sown with a disk drill.

When velvetbeans are grown with corn, which is the common practice in much of the southern half of the Cotton Belt, wheat can not be sown in the standing corn; neither can the crop be removed in time for fall seeding. It is necessary, then, that wheat follow some other crop than corn. Fortunately, better yields of wheat can be expected following cotton than after corn.

For the northern part of the Cotton Belt the rotation may be as follows:

(1) Cotton, with crimson clover sown at the last cultivation, or hairy vetch or Austrian field peas sown in cotton middles in September or early October and plowed under the following spring.

(2) Corn, with cowpeas sown between the rows at the last cultivation.

(3) Wheat, followed by cowpeas, followed by rye, to be turned under in the spring. The cowpeas following the wheat crop may be cut for hay, or they may be disked in or plowed under as green manure.

In tobacco-growing sections wheat may follow tobacco in the rotation.

PREPARATION OF THE SEED BED

When wheat follows a cultivated crop that is removed sufficiently early, such as corn or tobacco, the soil can usually be prepared for seeding by the use of a disk and ordinary harrows. As soon as the crop is harvested the land should be gone over with the disk to prevent the growth of grass and weeds. A second disking, followed by harrowing, is given just before the grain is sown. A better seed bed can be prepared in this way than by plowing, and it takes much less time and work. If weeds are plentiful, plowing 3 or 4 inches deep may be necessary. Harrowing with an ordinary harrow should follow the plowing.

When wheat follows cotton the stalks should be plowed under as soon as the bolls are all open and picked. Plowing in this case should be deep enough to bury the stalks completely in order to destroy the boll weevil. The land should then be firmed with a roller and the wheat sown with a disk drill. Disking or harrowing is not advisable, as it unearths the buried stalks.

When wheat follows other than a cultivated crop, the seed bed should be prepared by plowing the land to a depth of 6 or 7 inches several weeks before seeding. It should then be harrowed at once and afterwards worked down with a harrow, disk, drag, or roller in such a manner as to kill all weeds that start to grow after rains and to settle the subsoil and keep the topsoil well broken up. Figure 1 shows disking and harrowing at a single operation. When it is necessary to plow just before seeding, as when a catch crop of cowpeas is plowed under, the soil should be compacted by rolling and harrowing several times before seeding. In any case, when it is time to sow the grain, a fine, mellow seed bed should be prepared, using the harrow or other tools if necessary.

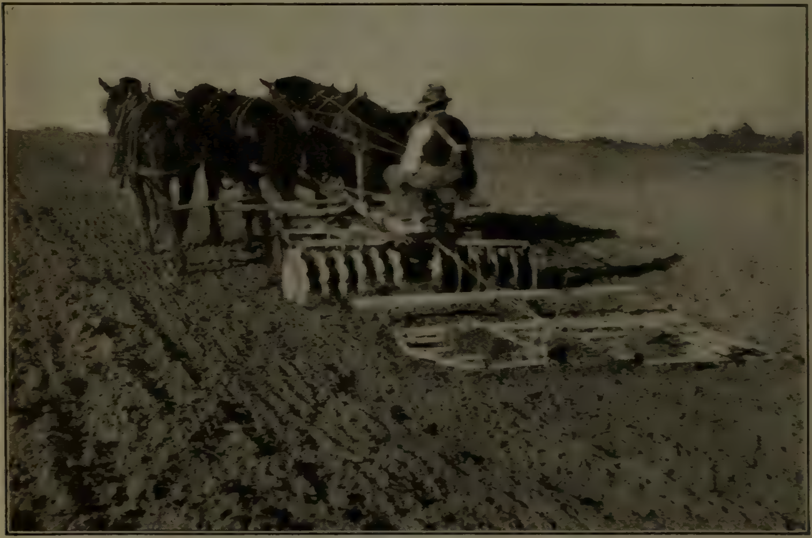

FIGURE 1.—Disking and harrowing land at a single operation

PREPARING AND SOWING THE SEED

PREPARATION OF SEED FOR SOWING

Only clean seed of an adapted variety should be used. Broken, immature, weevil-eaten, and shriveled grains, weed seeds, and all foreign material should be removed by fanning and grading the seed before it is sown. The fanning mill will also remove smut balls and many grains affected by scab, as these are lighter than the sound grain. On account of the many advantages from using clean seed, the fanning mill should be used generally. There should be at least one in each community. If individuals find the cost too high, several farmers may often find it desirable to own a mill in common. Wheat prepared for sowing is shown in Figure 2.

Where stinking smut is present, seed wheat should be treated with copper carbonate.

Reliable seed dealers can generally furnish good wheat seed, or, better still, good seed can often be obtained of a local grower who is a member of the State crop-improvement association. Officers of the State agricultural experiment stations and county agents can usually refer growers to sources of good seed.

METHOD OF SOWING

After a good seed bed is prepared, the properly fanned and treated seed should be sown about 1½ inches deep with a grain drill, if such an implement is available. The drill rows should be from 6 to 8 inches apart. The same drill that is used for seeding oats or barley can be used for wheat. A disk drill, shown in Figure 3, is preferable to the hoe or shoe drill where weeds and trash cover the land or where cotton stalks are plowed under. Such material is less likely to clog and be uncovered by the disk drill. On clean land, however, any kind of a drill may be used. By the use of a drill the seed is covered uniformly and placed in contact with moist soil, where it will germinate readily. Many experiments have shown that better results are obtained by sowing with a drill than by sowing broadcast.

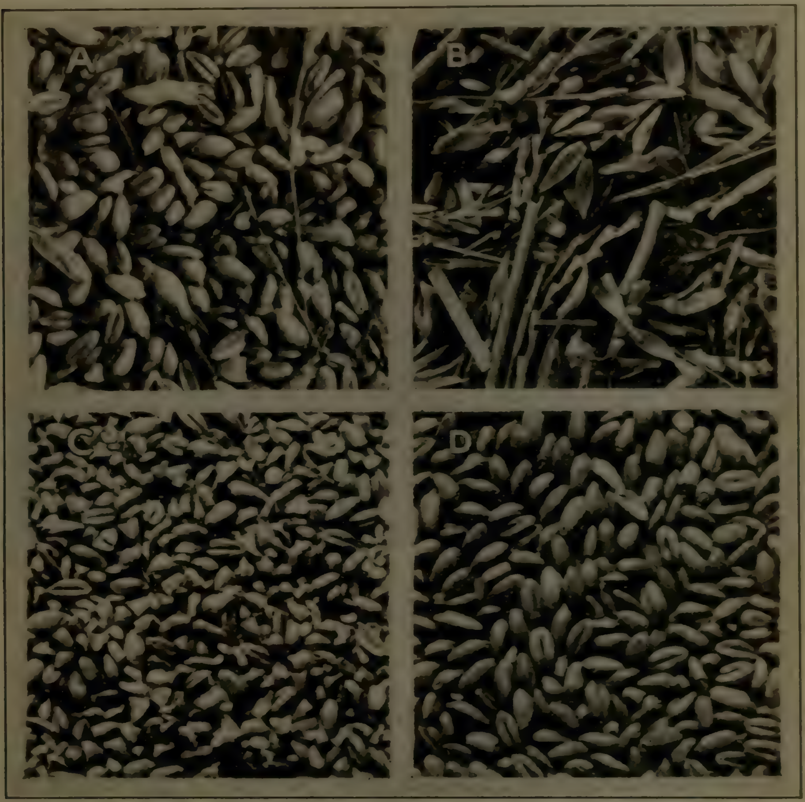

FIGURE 2.—Preparation of seed wheat: A, Original grain containing weed seeds, foreign material, and smut balls; B, coarse material; C, small weed seeds and broken and small-sized wheat kernels removed in cleaning; D, seed wheat after cleaning and dusting with copper-carbonate dust

When a drill is not available, however, wheat may be sown broadcast over the field from a 2-bushel bag slung over the shoulder and under one arm. The sown seed should then be covered by harrowing with an ordinary harrow. The use of broadcast seeders would lighten this labor, but such implements are almost unknown in the South. The man sowing the grain saves much labor and can sow more evenly and rapidly if he scatters the seed while standing or sitting in the rear end of a wagon being drawn slowly back and forth across the field. About one-fourth more seed should be sown broadcast than if drilled, as more seed is wasted.

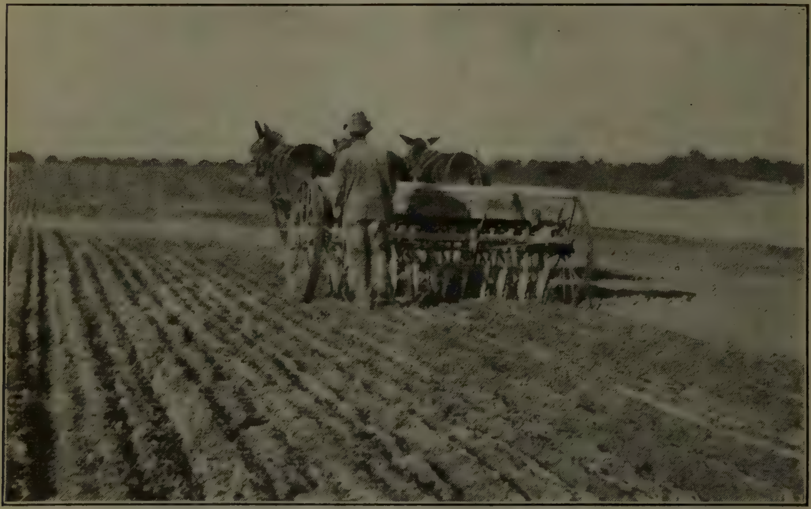

FIGURE 3.—A disk drill in operation

TIME OF SOWING

Wheat can be sown in the Southeastern States over a rather long period, extending from the latter part of September in the uplands of Tennessee and North Carolina to the latter part of November near the Gulf. The best time for seeding is about October 1 in the northern part and November 15 in the southern part. It will be necessary to delay seeding until about the average date of the first killing frost where the Hessian fly threatens. There is a further discussion of time of seeding in connection with the statements on the Hessian fly. (See p. 7.)

A good growth of the plant is necessary before cold weather begins, yet if the plant becomes jointed injury from freezing may result. If seeding is delayed until very late in the winter, sufficient winter growth is not secured and hot summer weather may injure or destroy the crop.

RATE OF SOWING

The quantity of seed that should be sown under ordinary conditions is 6 pecks per acre. This may be varied according to the size of kernel of the variety used, the condition of the seed bed, the fertility and character of the soil, and the date of seeding. When a drill is used for sowing and the grains are small, the seed bed in good condition, the soil rich, warm, and well drained, and the seeding early, 5 or even 4 pecks per acre are often sufficient. When the seed is sown broadcast and opposite conditions exist, 7 or 8 pecks may give more profitable results. It is advisable to adhere to these rules with all varieties, regardless of any claims of exceptional tillering ability that may be made.

VARIETIES

A variety that has been grown locally for several years and has become adapted to the locality is generally the best. The soft red winter wheats are best, considered from all standpoints, although the soft white winter wheats (not the Pacific coast white wheats) of the Northeastern States are well adapted. Beardless smooth-chaffed varieties of red wheat (fig. 4), such as the Fultz, Purplestraw, Bluestem (not the Spring Bluestem), Georgia Red, Leap Prolific, Red May, Redhart, and Currell, or bearded smooth-chaffed varieties (fig. 5), such as Fulcaster, Dietz, and Red Wonder, may be grown with the greatest chance for success. The hard red winter wheats, such as Turkey and Kharkof, should not be sown in the South. The spring wheats of the upper Mississippi Valley may come through the winter, but are not well suited to this section. The durum wheats also are not suitable for this section.

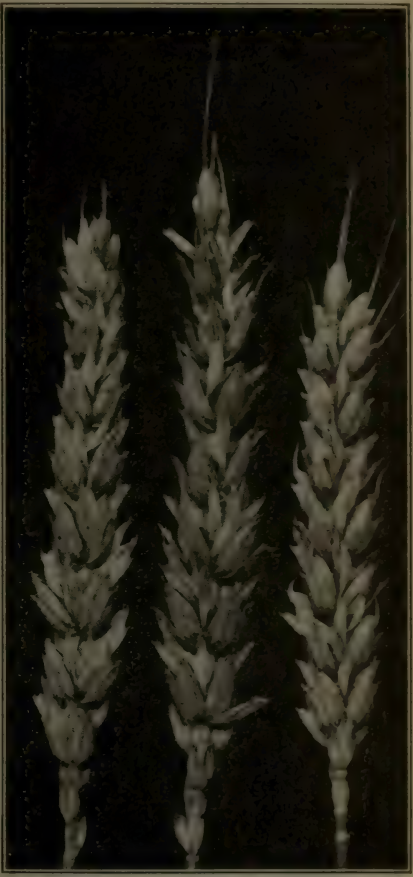

FIGURE 4.—Three beardless wheats (left to right)—Fultz, Leap, and Purplestraw

PESTS OF THE WHEAT CROP

INSECTS

HESSIAN FLY

The Hessian fly is a destructive pest of the wheat crop in some parts of the Piedmont and mountainous sections of the Southeastern States. It does not seem to have reached the coastal plain. Where this insect is present it is advisable to take precautionary measures to prevent injury by it.

The Hessian fly, being found in the "flaxseed" stage in wheat stubble and in unharvested wheat from June till September, or even

October in the South, can be destroyed or its damage prevented by carrying out the following methods of control:

(1) When the fly threatens do not sow wheat until after a fly-free date, which is approximately October 10 for the northern boundary of Tennessee and North Carolina, October 20 for the southern boundary of these States, and October 27 for all places having the approximate latitude of Atlanta.

(2) Where possible plow under deeply all stubble and ruined wheat fields immediately after harvest in order to bury the "flaxseeds," so that the flies can not emerge. Such land can be sown at once to cowpeas or soybeans if desired.

(3) Harrow, disk, pasture, or otherwise effectually prevent the growth of all volunteer wheat.

(4) As a measure preparatory to sowing wheat, plow as early and deeply as existing conditions will permit; disk, harrow, and roll until a thoroughly pulverized, compact seed bed is obtained.

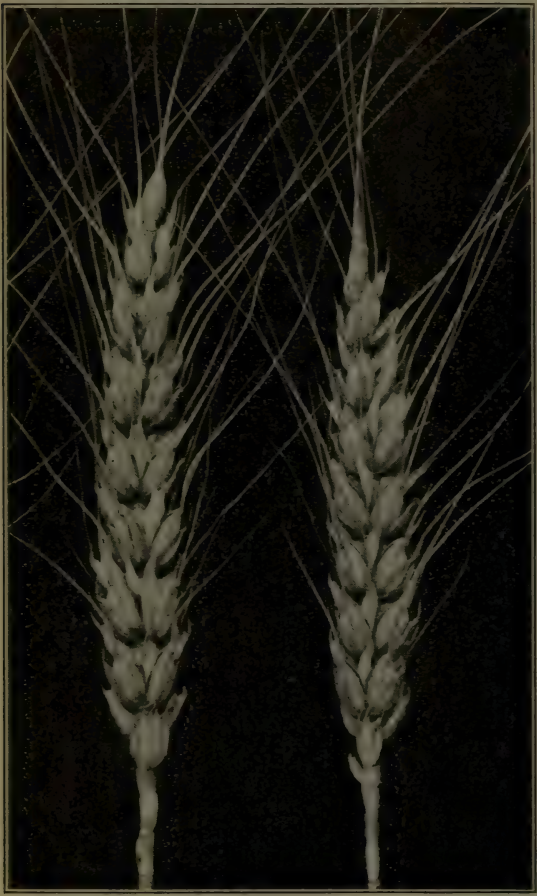

FIGURE 5.—Heads of Fulcaster, a bearded wheat

Where stubble fields can not be cultivated because of seedings of clover or grass, the only practicable method that the farmer can use is that of delaying his wheat sowing until the flies have made their way from the stubble to the fields and died there without being able to find any plants upon which to deposit their eggs. Late-sown wheat is also less liable to be injured by fall infections of rust.

The most serious objection to the most practicable and effective method that can be employed to control this pest in the field—namely, late sowing—is that there is danger of so delaying the growth of the plants that they do not become sufficiently advanced to enable them to withstand the winter. The ill effects of late sowing can be largely avoided by good farming practices. The most practicable and effective methods of controlling the Hessian fly are identical with the best methods of producing the maximum yields of wheat. It is perfectly possible for the farmer to fight the Hessian fly by the process of good farming, involving thorough cultivation, good seed, and a rotation of crops, and by the application of fertilizer containing readily available plant food along with the grain at the time of sowing.

INSECTS INJURIOUS TO STORED GRAIN

The most serious damage to wheat in shock, stack, or bin is done by the Angoumois grain moth and the black weevil.[2] These insects may be destroyed in grain stored in bins or barrels by the use of liquid carbon disulphide.

Place the grain in air-tight bins holding 30 to 40 bushels. Place 1 pound of carbon disulphide in a shallow vessel on top of the grain and cover the top of the bin as tightly as possible. The liquid readily vaporizes, and the fumes, being heavier than air, pass down through the grain, destroying all insects. This method is most effective when the temperature is above 75° F.

DISEASES

SMUTS

The smuts are common diseases of wheat in the Southeastern States. There are two of them, stinking smut, or bunt, and loose smut. (Figs. 6 and 7.) They can be distinguished easily, since stinking smut has a distinct, disagreeable odor which can be recognized in the threshed grain, while loose smut does not have such an odor. Stinking smut when present forms smut balls, consisting of a compact mass of dark-brown spores within a thin, gray membrane. When these smut balls are crushed, only a dark-colored, dustlike material remains. In heads affected by loose smut the kernels are entirely destroyed, and there is left in the field just before harvest only the rachis or central stem of the head.

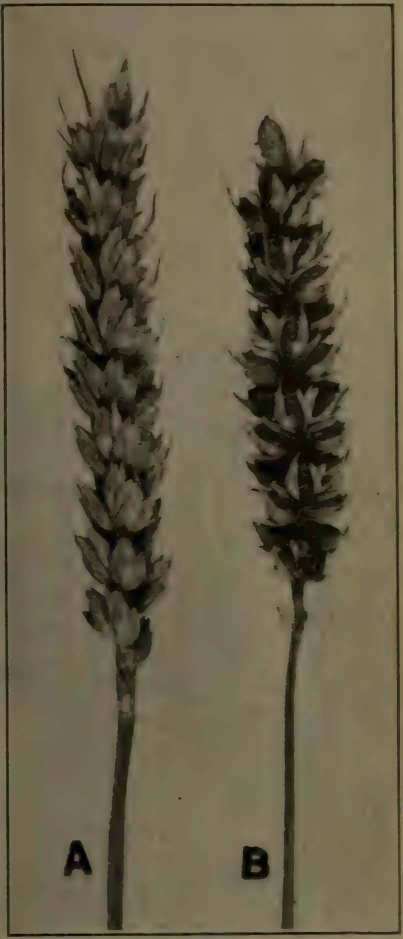

FIGURE 6.—A, Sound head of wheat; B, bunted head

Usually loose smut of wheat does not cause much loss, but sometimes losses from it are rather heavy. It is not unusual to find 5 to 10 per cent of the heads in a field destroyed by it.

Loose smut can not be controlled by chemicals, but can be controlled by hot-water treatment. The hot-water treatment, however, is difficult to apply and is not generally practicable for farmers to use.[3] Some farmers get rid of loose smut by treating enough seed to sow a seed plot an acre or more in size, separated some distance from other wheat. If the treatment is properly done, the grain from this plot will be free from loose smut and will produce a crop free of this smut the next year.

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[2] Detailed information concerning these pests and complete directions for destroying them are contained in Farmers' Bulletin 1483.

[3] Directions for treating seed wheat with hot water are given in Farmers' Bulletin 1540, Smuts of Wheat and Rye and Their Control.

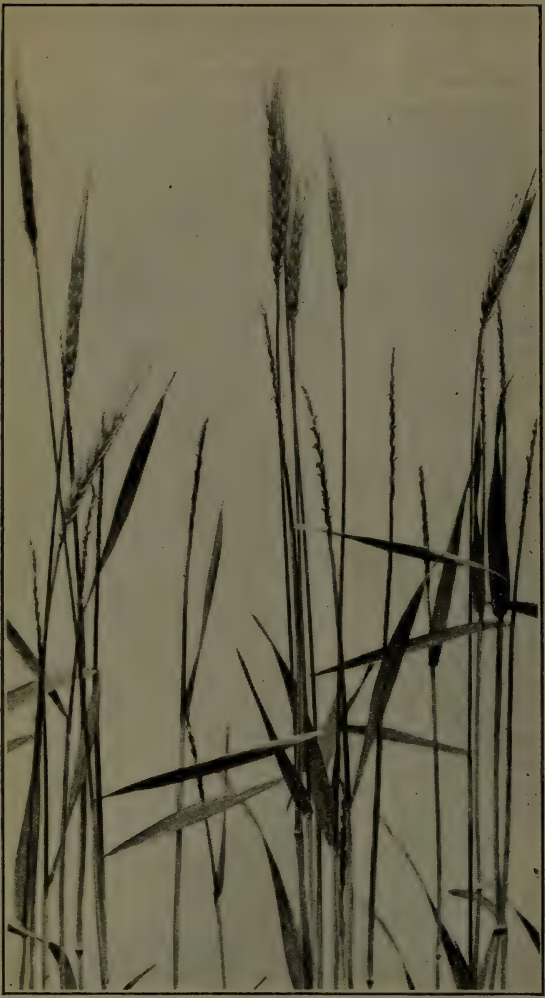

FIGURE 7.—Loose smut of wheat as it appears in the field about two weeks before ripening

Stinking smut, or bunt, causes large losses each year in reduced yield and in discounts at the market. Much of this loss can be prevented by treating the seed with copper-carbonate dust. This treatment is cheap, easy to apply, and does not injure the seed. Directions for using copper carbonate in treating wheat are as follows:[4]

Thoroughly clean the seed with a fanning mill to remove smut balls. Use 2 to 3 ounces of copper carbonate to a bushel of wheat. The copper carbonate must be spread evenly over every kernel. This is best done by thoroughly mixing the grain and the dust in a tight commercial or homemade mixer. Such a mixer can be made of a 30-gallon oil drum or a 30-gallon or 40-gallon barrel mounted on a frame by means of an axle and provided with a handle for turning over and over in mixing, as shown in Figure 8.

Copper carbonate is poisonous, so treated seed must not be used for food or feed. Wear a mask over the nose and mouth when treating grain, and treat only in a well-ventilated place. To avoid breaking the grain drill used in sowing treated seed, turn the feed shafts with a wrench after the drill has stood overnight. Also oil the gear bearings frequently.

RUST

The disease most injurious to wheat and the factor that usually limits yields the most in the Southeastern States is rust. This affects both stems and leaves, reddish and black spots forming on these parts. Its development is favored by dampness and heat. It is most destructive on low, damp land. Early-ripening varieties will generally be less affected than late varieties. There are no rustproof varieties for the South, but some are more resistant than others. Sowing on fertile, well-drained uplands and the use of early varieties are the most successful methods of combating the disease. Seed treatments are not effective in preventing rust.

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[4] Fuller directions for this treatment and descriptions of apparatus for treating seed are contained in Miscellaneous Circular 108, Copper-Carbonate Seed Treatment for Stinking Smut of Wheat, and Farmers' Bulletin 1540, both issued by the U. S. Department of Agriculture.

WEEDS

Cheat, or chess, is often found in wheat fields and in the threshed grain. When present it lowers the quality of wheat for milling purposes. Cheat is not as easily winterkilled as wheat and will endure more unfavorable conditions. This has caused many people to believe that wheat turns to cheat. This is not true, for cheat grows only from cheat seed, usually sown with the wheat. The fanning mill will remove most of these seeds.

Wild onion or garlic is the worst weed pest in many southern wheat fields. It is very difficult to remove from the threshed grain and to eradicate from farms. Wheat containing onions is usually docked heavily. Bread made from garlicky flour, especially if eaten warm, has a pronounced odor and flavor. Avoid sowing wheat containing onion bulblets, and use every means to rid the farm of wild onions if they are already established.[5]

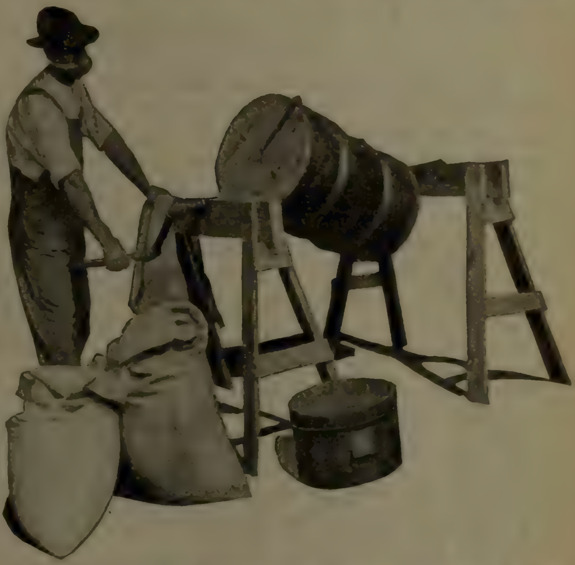

FIGURE 8.—Treating wheat with copper carbonate to prevent stinking smut (bunt), using a machine made from an oil drum fitted with axle and handle and also with a hinged tight-fitting door in the head

Cockle has black, rough seeds which have about the same diameter as wheat kernels. They can not be removed easily and are very injurious to flour. Special care should be taken to sow only seed free from cockle and to remove all plants that appear in wheat fields.

Peppergrass is another weed of southern wheat fields that should be guarded against. The seeds of this plant should be removed from the seed wheat before sowing by thorough fanning and grading.

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[5] Methods of eradicating wild onions are given in Leaflet 43 of the U. S. Department of Agriculture.

USES OF THE WHEAT CROP

WHEAT AS A NURSE AND COVER CROP

Winter wheat as a nurse crop for clover and grass seedings is inferior to winter barley, but superior to winter oats. Winter barley matures earlier than wheat and does not grow so tall. Winter oats make too dense a growth, while spring oats, in addition to their dense growth, occupy the land a longer time. When used as a nurse crop the stubble should be left high, to furnish protection and support to the young grass and clover plants. The shocked grain should be removed as early as possible after cutting, to avoid injury to the seeding. A good stand of wheat is also a valuable cover crop, preventing the washing of the soil and the leaching out and loss of plant food and fertilizers.

PASTURING AND MOWING

It frequently happens in the Southern States that an overabundance of foliage is produced in the fall and danger of winter injury is increased thereby. It is often advisable under these conditions to mow off the plants in the fall or pasture moderately. As growing wheat is an excellent feed, it is more profitable to dispose of the excess growth in the late fall or early spring by pasturing. However, excessive pasturing at any time, pasturing when the soil is wet, and late-spring pasturing are very injurious and should be entirely avoided. Lodging can be reduced by judicious mowing or pasturing.

WHEAT AS A PASTURE AND HAY CROP

Wheat is a better crop for pasture on the heavier clay soils than rye, but rye is much better on the sandy soils. Wheat can be pastured more closely without apparent injury than oats or barley. If wheat is to be cut for grain, however, it should not be pastured late in the spring. Wheat is an excellent hay crop, but is inferior to oats. It is superior to rye for this purpose.

HARVESTING THE CROP

MANNER OF CUTTING

The self-binder is most generally used for cutting wheat in the Southeastern States. The old method of cutting with a cradle can be used on very rough land and for small patches where wheat is not an important farm crop. For very small patches a hand sickle may be used.

In recent years the combine[6] (combined harvester-thresher) has been introduced and is being used with satisfactory results where conditions are favorable. The advantages of the combine in comparison with other methods of harvesting and threshing are the saving of labor, the elimination of transient labor, the early clearing of fields for tillage operations, the distribution of the straw on the land, and getting of the grain to market earlier. The disadvantages are the large investment required, the large amount of power consumed, the greater risk from damp grain, the greater risk to crops from storms, and the difficulty of saving the straw for feed and bedding. A combine should not be purchased for harvesting less than 100 to 150 acres of all crops each year. For smaller acreages other methods will usually be more economical.

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[6] The combine is discussed in Farmers' Bulletin 1565, Shall I Buy a Combine?

TIME OF CUTTING

Wheat may be cut safely with a binder when the straw has lost nearly all of its green color and the grains are not entirely hardened. If cut sooner than this, shriveled kernels will result. Wheat that is fully ripe is difficult to handle with a binder. Where the area of wheat is large, cutting should begin as early as it can be done safely.

When a combine is used to cut and thresh the grain in one operation, the grain must be left standing until it is fully ripe. This will usually be about 7 to 14 days after it is ready to cut with a binder. Cutting should begin as soon as the grain is dry enough to store safely. Wheat usually should contain not more than 14 per cent moisture in order to keep well in storage. If the crop is harvested at the proper stage of maturity and dryness, the grain will be equal in quality and condition to that harvested and threshed by other methods.

SHOCKING

Wheat should be shocked in the field immediately after being cut and bound. A shock is begun by standing two bundles in a nearly upright position with heads together and butts sufficiently apart to prevent falling over. From 8 to 12, and sometimes more, bundles are then set up about these until a round shock of the proper size is formed. The number of bundles to place in a shock depends upon the degree of ripeness, the length of straw, and the size of the bundle, fewer bundles being used where the straw is short or not fully ripe In placing the bundles the butts should be jammed into the stubble to insure firmness and the heads should lean inward sufficiently to prevent falling over. When this part of the shock is completed it should be covered as perfectly as possible with two bundles, the heads of which have been broken down at the band, to form a cap. This cap should be placed so as to protect the standing bundles from rain and sun as much as possible. If the heads of the cap are placed on the side of the shock toward the prevailing winds, some protection against blowing off may be afforded. A good shock is shown in Figure 9.

STACKING AND STORING

Threshing directly from the shock is the most common practice in this section. This should be done as soon as the grain is dry enough to store. It is often advisable to protect wheat by stacking or storing it in the barn as soon as it is dried out in the shock. The cost of threshing from the shock is generally somewhat less than the cost of stacking or storing in the barn and threshing from the stack or barn. Better protection is afforded the grain by stacking or storing, which is very important when threshing can not be done soon after cutting. A sweating process also takes place in the stack and barn, which improves to some extent the color, condition, and test weight of the grain and its milling and baking qualities. The additional cost, if any, resulting from stacking wheat is often offset by the better price received on account of the better quality. It is also possible in wet weather to thresh out the wheat more completely from the straw and to remove more of the chaff when stacking and storing are practiced.

Wheat in shocks or stacks or stored in barns may soon become infested with the Angoumois grain moth. This insect destroys the grain and sometimes causes severe losses. Prompt threshing is advisable wherever this moth occurs. The threshed grain when placed in the bin can be protected by treating the grain with carbon disulphide to destroy the insects.

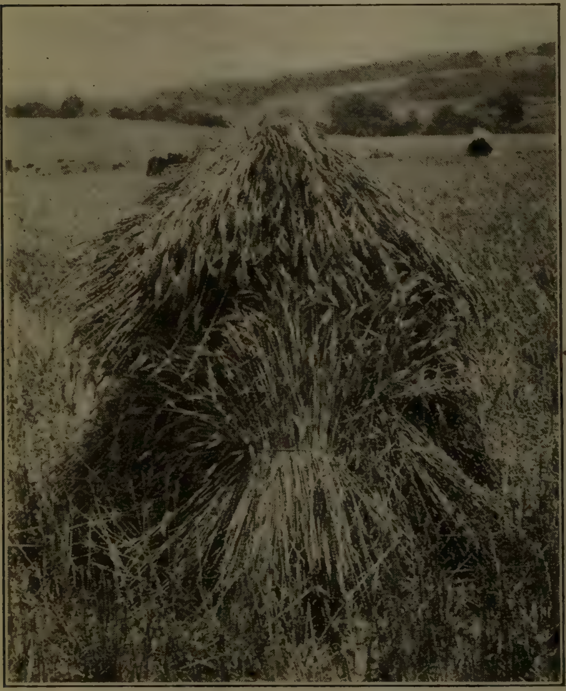
FIGURE 9.—A shock of wheat

THRESHING

Threshing should not be attempted when wheat or straw is wet or tough, as good results can not then be obtained. Wheat can dry out much better in the head than after being threshed. If threshed wet and marketed immediately it is discounted heavily in price; if placed in a bin it is likely to become hot and badly damaged.

The wheat straw may be stacked in the open, stored in the mow, or spread at once over the field. When the price is good it may be sold. It should never be burned. Straw furnishes excellent roughage for livestock, and by using it for bedding in stalls a large part of the valuable liquid manure can be preserved. Rotted straw from an old straw pile or from straw spread directly on the field makes good manure, as each thousand pounds of straw contains on the average about 8 pounds of potassium, 5 pounds of nitrogen, and smaller amounts of other important plant foods. A thousand pounds of wheat grain removes on the average about 20 pounds of nitrogen and about 3½ pounds each of potassium and phosphorus.

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WHEAT GROWING IN THE SOUTHEASTERN STATES

Revised edition entered in [illegible]

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FARMERS' BULLETIN 885
UNITED STATES DEPARTMENT OF AGRICULTURE

Aug 25-1917

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. August, 1917

Show this bulletin to a neighbor. Additional copies may be obtained free from the Division of Publications, United States Department of Agriculture

THE FARMERS in the six Southeastern States—Tennessee, North Carolina, Mississippi, Alabama, Georgia, and South Carolina—are encouraged to increase their wheat acreage on land suitable for the crop, as it leads to crop diversification and provides home-grown bread.

The sandy loam, silt loam, loam, and many of the clay soils when well drained and fertile are suited to wheat production. The lighter sandy soils, especially in the Coastal Plain, are better adapted for rye.

It is necessary to apply fertilizers to most of the southern soils, phosphorus being the principal element needed. Lime is also generally necessary for the best results.

Wheat should be grown only in rotation including legumes and cultivated crops.

Make the seed bed a fit place for the seed.

Fan and grade all seed before sowing, to remove trash and weed seeds, and treat with formaldehyde when the seed is infected with smut.

Soft red winter wheats are best, considered from all standpoints.

Home-grown seed should be used when it can be secured.

Late sowing is the most practicable and effective method of controlling the Hessian fly, but good farm practice is necessary for the best results when wheat is sown late.

Wheat will furnish much pasture for stock in the fall and winter.

WHEAT GROWING IN THE SOUTHEASTERN STATES.

CONTENTS.

	Page.
Increase in the wheat area	3
Cost of production and yields per acre	3
Soils adapted to wheat	4
Fertilizers	4
Rotations	5
Preparation of the seed bed	6
Preparing and sowing the seed	6
Varieties	8
Pests of the wheat crop	8
Uses of the wheat crop	12
Harvesting the crop	13

INCREASE IN THE WHEAT AREA.

THIS BULLETIN is written for wheat growers in the six Southeastern States—Tennessee, North Carolina, Mississippi, Alabama, Georgia, and South Carolina. No mention is made here of Florida, because wheat is not adapted to that State and is not successfully grown in it. The acreage of wheat has been increasing in these six States for several years past. Encouragement is given to this increase, as it leads to crop diversification and provides home-grown bread. Wheat can be grown on many of the heavier soils of these States. On the lighter, sandy soils, rye, also a bread grain, is better adapted.

In connection with the increase in the acreage of bread grains in this section attention must be given to the milling facilities. Local mills must be provided or it will be necessary to ship out the grain raised and ship in the flour.

COST OF PRODUCTION AND YIELD PER ACRE.

The cost of production has increased considerably in recent years. On the other hand, the price of grain has increased greatly. The enhanced price of wheat will result in greater returns than recently from the crop. More attention to wheat production on the part of farmers in general may also result in making the wheat crop as valuable in certain sections of the South as in any part of the country.

The average yields per acre in bushels for the 10 years, 1907 to 1916, for these States have been as follows: Tennessee, 11.1; North Carolina, 10.5; Mississippi, 13.6; Alabama, 11.2; Georgia, 10.7; South Carolina, 10.4.

SOILS ADAPTED TO WHEAT.

Wheat does best on well-drained loam, silt loam, and some of the clay soils. Light, sandy soils and heavy, poorly drained clay soils are not desirable for wheat. Since there is so much sandy land in the Coastal Plain, wheat is not a crop that can be generally grown there. On the heavier types of sandy loam soils in the Coastal Plain, however, good wheat yields can be obtained. Rye is a better crop than wheat on the light, sandy lands. The Piedmont and mountainous sections of the Southeastern States contain much good wheat land.

Wheat should not be sown on land the drainage of which is poor. If the land is subject to overflow or if water stands on it after rains, wheat should not be sown, for the plants will not live and thrive on such land. Low places in fields can often be drained sufficiently to prevent injury from standing water by opening furrows in the direction of the natural slope. An excessive amount of water in the soil is liable to result in winterkilling. A soil to be good for wheat should contain plenty of vegetable matter and plant food and should not be acid.

FERTILIZERS.

For soils that are not in a good state of fertility for wheat the following application of fertilizer per acre, applied when the grain is sown, will be generally profitable:

Slaked lime or ground limestone, 1,000 to 4,000 pounds; applied two or three weeks before sowing.

Acid phosphate, 250 pounds; potash salts,[1] 25 to 50 pounds; nitrate of soda, 25 pounds; applied when the seed is sown.

Nitrate of soda, 50 to 75 pounds; applied after growth starts in the spring, generally early in March.

In place of these applications a 10–3–3 fertilizer, that is, one containing 10 per cent of phosphorus and 3 per cent each of nitrogen and potassium, may be used. Of this, 150 to 250 pounds per acre on the richer lands and 250 to 350 pounds on the poorer lands, may be applied when the wheat is sown. If some other formula of about the same composition is more readily obtainable it may be used. The principal requirement is a large amount of phosphorus and smaller amounts of the other elements. Under the present war conditions little, if any, potassium should be used.

Most of the southern soils are acid and are benefited by an application of lime either as slaked lime or ground limestone. Lime can be applied through the grain drill or lime spreader, preferably several weeks before the seed is sown. It may also be scattered over the plowed land with a shovel and harrowed in. There are some waxy limestone soils in central Alabama and northeastern Mississippi, and limestone valleys in several States, which, without lime are suitable for wheat if sufficient vegetable matter is incorporated in them. Nitrogen usually can be added most cheaply by growing legumes, such as velvet beans, cowpeas, soy beans, or the clovers. Phosphorus is generally deficient in southern soils and must be added as acid phosphate, steamed bone, etc., or in a complete fertilizer.

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[1] It is not advisable to apply potash salts at present (1917) prices. This recommendation is made for normal conditions.

The best fertilizer to build up the land in preparation for wheat is 5 or 6 tons per acre of barnyard manure, to each ton of which 40 to 50 pounds of acid phosphate or rock phosphate (floats) is added before spreading. It is advisable to apply the manure to a preceding cultivated crop, such as potatoes or corn; otherwise, a heavy growth of straw and consequent lodging may result. If green manure, such as cowpeas or clover, is plowed under, 200 to 250 pounds of acid phosphate should be added per acre.

ROTATIONS.

Wheat should be grown only in rotation including legumes and cultivated crops. Local conditions should determine the rotation and the particular crop to be used. Wherever possible, wheat should follow some legume crop, such as cowpeas or soy beans, as better yields are obtained after these crops than after corn.

In the southern part of the cotton belt, where the boll weevil is a serious pest, the following rotation is giving good results:

First year.—Cotton. The cotton stalks plowed under early and wheat sown.

Second year.—Wheat, followed by cowpeas or soy beans to be cut for hay.

Third year.—Corn and velvet beans. Beans and cornstalks pastured and turned under in early spring for cotton.

Good farm practice under boll-weevil conditions requires that the cotton stalks be plowed under as soon as the bolls are all open and picked, care being taken to cover the stalks completely in order to destroy the insects. The land should then be gone over with a roller and the wheat sown with a disk drill. Harrowing is not advisable, as it unearths the buried stalks.

When velvet beans are grown with corn, which is the common practice in much of the southern half of the cotton belt, wheat can not be sown in the standing corn; neither can the crop be removed in time for fall seeding. It is necessary then that wheat follow some other crop than corn. Fortunately, better yields of wheat can be expected following cotton than after corn.

For the northern part of the cotton belt the rotation may be as follows:

(1) Cotton, with crimson clover sown at the last cultivation and plowed under the following spring.

(2) Corn, with cowpeas sown between the rows at the last cultivation.

(3) Wheat, followed by cowpeas, followed by rye, to be turned under in the spring. The cowpeas following the wheat crop may be cut for hay, or they may be disked in or plowed under as green manure.

In tobacco-growing sections wheat may follow tobacco in the rotation.

PREPARATION OF THE SEED BED.

When wheat follows a cultivated crop that is removed sufficiently early, such as corn or tobacco, the soil can usually be prepared for seeding by the use of a disk and ordinary harrows. As soon as the crop is harvested the land should be gone over with the disk to prevent the growth of grass and weeds. A second disking, followed by harrowing, is given just before the grain is sown. A better seed bed can be prepared in this way than by plowing, and it takes much less time and work. If weeds are plentiful, plowing 3 or 4 inches deep may be necessary. Harrowing with an ordinary harrow should follow the plowing.

When wheat follows cotton the stalks should be plowed under as soon as the bolls are all open and picked. Plowing in this case should be deep enough to bury the stalks completely in order to destroy the boll weevil. The land should then be firmed with a roller and the wheat sown with a disk drill. Disking or harrowing is not advisable, as it unearths the buried stalks.

When wheat follows other than a cultivated crop, the seed bed should be prepared by plowing the land to a depth of 6 or 7 inches several weeks before seeding. It should then be harrowed at once and afterwards worked down with a harrow, disk, drag, or roller in such a manner as to kill all weeds that start to grow after rains and to settle the subsoil and keep the topsoil well broken up. When it is necessary to plow just before seeding, as when a catch crop of cowpeas is plowed under, the soil should be compacted by rolling and harrowing several times before seeding. In any case, when it is time to sow the grain, a fine, mellow seed bed should be prepared, using the harrow or other tools if necessary.

PREPARING AND SOWING THE SEED.

PREPARATION OF THE SEED FOR SOWING.

Broken, immature, weevil-eaten, and shriveled grains, weed seeds, and all foreign material should be removed by fanning and grading the seed before it is sown. The fanning mill will also remove smut balls and many grains affected by scab, as these are lighter than the sound grain. On account of the many advantages from using clean seed the fanning mill should be used generally. There should be at least one in each community. If individuals find the cost too high, several farmers may often find it desirable to own a mill in common.

Where stinking smut is present seed wheat should be treated with a solution of commercial formaldehyde in water. Detailed directions for such treatment are given on a later page.

Reliable seed dealers can generally furnish good wheat seed, or, better still, good seed can often be obtained of a local grower. Officers of the State agricultural experiment stations and county agents can usually refer growers to sources of good seed.

METHOD OF SOWING.

After a good seed bed is prepared, the properly fanned and treated seed should be sown about 1½ inches deep with a grain drill, if such an implement is available. The drill rows should be from 6 to 8 inches apart. The same drill that is used for seeding oats or barley can be used for wheat. A disk drill is preferable to the hoe or shoe drill where weeds and trash cover the land or where cotton stalks are plowed under. Such material is less likely to clog and be uncovered by the disk drill. On clean land, however, any kind of a drill may be used. By the use of a drill the seed is covered uniformly and placed in contact with moist soil, where it will germinate readily. Many experiments have shown that better results are obtained by sowing with a drill than by sowing broadcast.

When a drill is not available, however, wheat may be sown broadcast over the field from a 2-bushel bag slung over the shoulder and under one arm. The sown seed should then be covered by harrowing with an ordinary harrow. The use of broadcast seeders would lighten this labor, but such implements are almost unknown in the South. The man sowing the grain saves much labor and can sow more evenly and rapidly if he scatters the seed while standing or sitting in the rear end of a wagon being drawn slowly back and forth across the field. About one-fourth more seed should be sown broadcast than if drilled, as more seed is wasted.

TIME OF SOWING.

Wheat can be sown in the Southeastern States over a rather long period, extending from the latter part of September in the uplands of Tennessee and North Carolina to the latter part of November near the Gulf. The best time for seeding is about October 1 in the northern part and November 15 in the southern part. It will be necessary to delay seeding until about the average date of the first killing frost where the Hessian fly threatens. There is a further discussion of time of seeding in connection with the statements on the Hessian fly. (See p. 8.)

A good growth of the plant is necessary before cold weather begins, yet if the plant becomes jointed injury from freezing may result. If seeding is delayed until very late in the winter, sufficient winter growth is not secured and hot summer weather may injure or destroy the crop.

RATE OF SOWING.

The quantity of seed that should be sown under ordinary conditions is 6 pecks per acre. This may be varied according to the size of kernel of the variety used, the condition of the seed bed, the fertility and character of the soil, and the date of seeding. When a drill is used for sowing and the grains are small, the seed bed in good condition, the soil rich, warm, and well drained, and the seeding early, 5 or even 4 pecks per acre are often sufficient. When the seed is sown broadcast and opposite conditions exist, 7 or 8 pecks may give more profitable results. It is advisable to adhere to these rules with all varieties, regardless of any claims of exceptional tillering ability that may be made.

VARIETIES.

A variety that has been grown locally for several years and has become adapted to the locality is generally the best. The soft red winter wheats are best, considered from all standpoints, although the soft white winter wheats (not the Pacific coast white wheats) of the Northeastern States are well adapted. Beardless, smooth-chaffed varieties of red wheat, such as the Fultz, Purple Straw, Bluestem (not the Spring Bluestem), Georgia Red, Leap Prolific, Golden Chaff, and Currell, or bearded, smooth-chaffed varieties, such as Fulcaster, Dietz, and Red Wonder, may be grown with the greatest chance for success. The hard red winter wheats, such as Turkey and Kharkof, should not be sown in the South. The spring wheats of the upper Mississippi Valley may come through the winter, but are not well suited to this section. The durum wheats also are not suitable for this section.

PESTS OF THE WHEAT CROP.

INSECTS.

HESSIAN FLY.

The Hessian fly is a destructive pest of the wheat crop in some parts of the Piedmont and mountainous sections of the Southeastern States. It does not seem to have reached the Coastal Plain. Where this insect is present it is advisable to take precautionary measures to prevent injury by it.

The Hessian fly, being found in the "flaxseed" stage in wheat stubble and in unharvested wheat from June till September, or even

October in the South, can be destroyed or its damage prevented by carrying out the following methods of control:

(1) When the fly threatens do not sow wheat until after a fly-free date, which is approximately October 20 for the northern boundary of Tennessee and North Carolina, October 25 for the southern boundary of these States, and November 1 for all places having the approximate latitude of Atlanta.

(2) Burn, where possible and safe, all stubble and ruined wheat.

(3) Where burning is impracticable, disk or plow all stubble and ruined wheat immediately after harvest and put in a legume crop, such as cowpeas or soy beans.

(4) Plow under deeply all stubble and ruined wheat fields before August 15, harrow the ground, and roll if necessary.

(5) Harrow, disk, pasture, or otherwise effectually destroy all volunteer wheat.

(6) As a measure preparatory to sowing, plow as early and deeply as existing conditions will permit; disk, harrow, and roll until a thoroughly pulverized, compact seed bed is obtained.

Where stubble fields can not be burned over or cultivated because of seedings of clover or grass, the only practicable method that the farmer can use is that of delaying his wheat sowing until the flies have made their way from the stubble to the fields and died there without being able to find any plants upon which to deposit their eggs.

Best cultural methods advocated in combating Hessian fly.—The most serious objection to the most practicable and effective method that can be employed to control this pest in the field—namely, late sowing—is that there is danger of so delaying the growth of the plants that they do not become sufficiently advanced to enable them to withstand the winter. The ill effects of late sowing can be largely avoided by good farming practices. The most practicable and effective methods of controlling the Hessian fly are identical with the best methods of producing the maximum yields of wheat. It is perfectly possible for the farmer to fight the Hessian fly by the process of good farming, involving thorough cultivation, good seed, and a rotation of crops, and by the application of fertilizer containing readily available plant food along with the grain at the time of sowing.

INSECTS INJURIOUS TO STORED GRAIN.

The most serious damage to wheat in shock, stack, or bin is done by the angoumois grain moth and the black weevil.[1] These insects may be destroyed in grain stored in bins or barrels by the use of liquid carbon disulphid.

Place the grain in air-tight bins holding from 30 to 40 bushels. Place 1 pound of carbon disulphid in a shallow vessel on top of the grain and cover the top of the bin as tightly as possible. The liquid readily vaporizes, and the fumes, being heavier than air, pass down through the grain, destroying all insects. This method is most effective when the temperature is about 75° F.

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[1] Detailed information concerning these pests and complete directions for destroying them are contained in Farmers' Bulletin 799.

DISEASES.

SMUTS.

The smuts are common diseases of wheat in the Southeastern States. There are two of them, the stinking smut, or bunt, and the loose smut. They can be distinguished easily, since the stinking smut has a distinct, disagreeable odor which can be recognized in the thrashed grain, while the loose smut does not have such an odor. The stinking smut when present forms smut balls, consisting of a compact mass of dark-brown spores within a thin, gray membrane. When these smut balls are crushed, only a dark-colored, dustlike material remains. In heads affected by loose smut the kernels are entirely destroyed, and there is left in the field just before harvest only the rachis or central stem of the head.

Treating the seed for smut.—The loose smut can not be controlled by formaldehyde treatment but can be controlled by hot-water treatment. The hot-water treatment, however, is difficult to apply and is not generally practicable for farmers to use. The stinking smut, or bunt, can be controlled and even eliminated by treating the seed with formaldehyde. The formaldehyde treatment is easy to apply. Formaldehyde can be purchased at any drug store at a cost of about 50 cents a pound. The proper strength of the solution for treating seed wheat is 1 pound of 40 per cent commercial formaldehyde to 40 gallons of water. The following method is effective for controlling smut:

> After running seed wheat through a fanning mill to remove the smut balls, spread it on a clean floor or on a tarpaulin and sprinkle the formaldehyde solution over the grain, using about 1 gallon to each bushel. The grain should be stirred thoroughly while being sprinkled, and the process should be continued until every kernel is wet. Then cover the grain with a canvas or some other heavy material and allow it to lie from one to five hours. It should then be uncovered and stirred occasionally until dry. It is then ready for seeding.

In treating grain care should be taken to have the solution the right strength. If too weak it will not kill the spores. If too strong it will injure the grain. Be sure the formaldehyde you buy is full strength. Wash out the drill with the formaldehyde solution. This will destroy any smut spores that may be in the drill.

Other effective methods of controlling stinking smut are as follows:

> (1) Prepare the formaldehyde solution in barrels. Put the grain to be treated in burlap sacks. Fill the sacks not more than half full and immerse them in the solution for 10 minutes; then hang them up to drain and dry. The sacks should be shaken occasionally to hurry the drying process.

(2) When all smut balls are not removed by the fanning process it is advisable to immerse the seed in a formaldehyde solution. There are several methods of doing this, one of the most convenient of which is as follows: A hole is bored at the bottom of each of two tubs or half barrels with handles. This hole is fitted with a plug and covered with a wire screen on the inside of the tub, so that grain can not pass through. One tub is set above the other. The upper tub is then filled two-thirds full with the formaldehyde solution and the seed poured in. As the seed is poured in and stirred, smut balls, chaff, and light kernels rise to the surface and are skimmed off. When the skimming is completed the plug is removed and the formaldehyde solution is allowed to drain into the tub beneath. The grain is then removed and spread out to dry. The empty tub is placed on the ground, the other tub on the stand, and the process is continued, more of the solution being added when necessary.

A convenient modification of this method is to provide two tubs, a large one and a smaller one, the latter made of substantial wire mesh or of iron or tin with a perforated plate or wire bottom. The larger tub is two-thirds filled with the formaldehyde, the other tub is set down in it, and the grain poured in and stirred. The smut balls and foreign material will again rise to the surface and can be skimmed off. When this is done the smaller tub containing the grain can be removed from the solution, which is allowed to drain off, and the grain is emptied on the floor and dried.[1]

RUST.

The disease most injurious to wheat and the factor that usually limits yields the most in the Southeastern States is rust. This affects both stems and leaves, reddish and black spots forming on these parts. Its development is favored by dampness and heat. It is most destructive on low, damp land. Early-ripening varieties will generally be less affected than late varieties. There are no rust-proof varieties for the South, but some are more resistant than others. Sowing on fertile, well-drained uplands and the use of early varieties are the most successful methods of combating the disease. Seed treatments are not effective in preventing rust.

WEEDS.

CHEAT, OR CHESS.

Cheat, or chess, is often found in wheat fields and in the thrashed grain. When present it lowers the quality of wheat for milling purposes. Cheat is not as easily winterkilled as wheat and will endure more unfavorable conditions. This has caused many people to believe that wheat turns to cheat. This is not true, for cheat grows only from cheat seed, usually sown with the wheat. The fanning mill will remove most of these seeds.

WILD ONION, OR GARLIC.

Wild onion, or garlic, is the worst weed pest in many southern wheat fields. It is very difficult to remove from the thrashed grain and to eradicate from farms. Wheat containing onions is usually docked heavily. Bread made from garlicky flour, especially if eaten warm, has a pronounced odor and flavor. Avoid sowing wheat containing onion bulblets and use every means to rid the farm of wild onions if they are already established.[1]

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[1] For a more complete discussion of the smuts of grain and of smut treatments, see Farmers' Bulletin 507.

COCKLE.

Cockle has black, rough seeds which have about the same diameter as wheat kernels. They can not be removed easily and are very injurious to flour. Special care should be taken to sow only seed free from cockle and to remove all plants that appear in wheat fields.

PEPPERGRASS.

Peppergrass is another weed of southern wheat fields that should be guarded against. The seeds of this plant should be removed from the seed wheat before sowing by thorough fanning and grading.

USES OF THE WHEAT CROP.

WHEAT AS A NURSE AND COVER CROP.

Winter wheat as a nurse crop for clover and grass seedings is inferior to winter barley, but superior to winter oats. Winter barley matures earlier than wheat and does not grow so tall. Winter oats make too dense a growth, while spring oats, in addition to their dense growth, occupy the land a longer time. When used as a nurse crop the stubble should be left high, to furnish protection and support to the young grass and clover plants. The shocked grain should be removed as early as possible after cutting, to avoid injury to the seeding. A good stand of wheat is also a valuable cover crop, preventing the washing of the soil and the leaching out and loss of plant food and fertilizers.

PASTURING AND MOWING.

It frequently happens in the Southern States that an overabundance of foliage is produced in the fall and danger of winter injury is increased thereby. It is often advisable under these conditions to mow off the plants in the fall or pasture moderately. As growing wheat is an excellent feed, it is more profitable to dispose of the excess growth in the late fall or early spring by pasturing. However, excessive pasturing at any time, pasturing when the soil is wet, and late spring pasturing are very injurious and should be entirely avoided. Lodging can be reduced by judicious mowing or pasturing.

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[1] Methods of eradicating wild onions are given in Farmers' Bulletin 610.

WHEAT AS A PASTURE AND HAY CROP.

Wheat is a better crop for pasture on the heavier clay soils than rye, but rye is much better on the sandy soils. Wheat can be pastured more closely without apparent injury than oats or barley. If wheat is to be cut for grain, however, it should not be pastured late in the spring. Wheat is an excellent hay crop, but is inferior to oats. It is superior to rye for this purpose.

HARVESTING THE CROP.

TIME OF CUTTING.

Wheat may be cut with safety when the straw has lost nearly all its green color and the grains are not entirely hardened. If cut sooner than this, shriveled kernels will result. If left standing until fully ripe, a bleached appearance, due to the action of the elements, often results, and loss from shattering may ensue. Wheat that is fully ripe is also more difficult to handle. Where the area of wheat is large, cutting should begin as early as it can be done safely.

MANNER OF CUTTING.

The self-binder is the best implement to use for cutting wheat in the Southeastern States. The old method of cutting with a cradle can be used on very rough land and for small patches where wheat is not an important farm crop. For very small patches a hand sickle may be used.

SHOCKING.

Wheat should be shocked in the field immediately after being cut and bound. A shock is begun by standing two bundles in a nearly upright position with heads together and butts sufficiently apart to prevent falling over. From 8 to 12, and sometimes more, bundles are then set up about these until a round shock of the proper size is formed. The number of bundles to place in a shock depends upon the degree of ripeness, the length of straw, and the size of the bundle, fewer bundles being used where the straw is short or not fully ripe. In placing the bundles the butts should be jammed into the stubble to insure firmness and the heads should lean inward sufficiently to prevent falling over. When this part of the shock is completed it should be covered as perfectly as possible with two bundles, the heads of which have been broken down at the band, to form a cap. This cap should be placed so as to protect the standing bundles from rain and sun as much as possible. If the heads of the cap are placed on the side of the shock toward the prevailing winds, some protection against blowing off may be afforded.

STACKING AND STORING.

Thrashing directly from the shock is the most common practice in this section. It is often advisable to protect wheat by stacking or storing it in the barn as soon as it is dried out in the shock. The cost of thrashing from the shock is generally somewhat less than the cost of stacking or storing in the barn and thrashing from the stack or barn. Better protection is afforded the grain by stacking or storing, which is very important when thrashing can not be done soon after cutting. A sweating process also takes place in the stack and barn, which improves to some extent the color, condition, and test weight of the grain and its milling and baking qualities. The additional cost, if any, resulting from stacking wheat is often offset by the better price received on account of the better quality. It is also possible in wet weather to thrash out the wheat more completely from the straw and to remove more of the chaff when stacking and storing are practiced.

THRASHING.

Thrashing should not be attempted when wheat or straw is wet or tough, as good results can not then be obtained. Wheat can dry out much better in the head than after being thrashed. If thrashed wet and marketed immediately it is discounted heavily in price; if placed in a bin it is likely to become hot and badly damaged.

The wheat straw may be stacked in the open, stored in the mow, or spread at once over the field. When the price is good it may be sold. It should never be burned. Straw furnishes excellent roughage for live stock, while by using it for bedding in stalls a large part of the valuable liquid manure can be preserved. Rotted straw from an old straw pile or from straw spread directly on the field makes good manure, as each thousand pounds of straw contains on the average about 8 pounds of potassium, 5 pounds of nitrogen, and smaller amounts of other important plant foods. A thousand pounds of wheat grain removes on the average about 20 pounds of nitrogen and about 3½ pounds each of potassium and phosphorus.

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HARVESTING SOY-BEAN SEED

W. J. MORSE
Scientific Assistant, Office of Forage-Crop Investigations

SUPERSEDED BY 1605

FARMERS' BULLETIN 886

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. September, 1917

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SOY BEANS yield more seed per acre and are more cheaply harvested than any other variety of bean.

The large commercial use of the soy bean for oil and for stock feed and the increased use of this bean for human food have resulted in an enormous increase in the acreage.

Soy beans for seed can be harvested with various farm implements, including the corn knife, the mower, the self-rake reaper, the self-binder, and the bean harvester, besides specially patented machines which harvest and thrash the seed at the same time.

Soy beans are easily cracked or split in thrashing. The best way to avoid this with the ordinary thrashing machine is to remove some of the concaves and reduce the speed of the cylinder one-half.

Machines constructed especially for thrashing soy beans are on the market. In any community where there is a considerable acreage of soy beans the purchase of one of these machines for community use will be found profitable.

Where only a small area of soy beans is grown the seed may be satisfactorily thrashed by flailing.

Soy-bean straw, after the seed has been thrashed, is a valuable feed. In some sections this is baled and sold on the market.

Soy-bean seed should be thoroughly dry before being stored. Only under exceptional conditions are soy-bean seeds attacked by weevils.

HARVESTING SOY-BEAN SEED.

CONTENTS.

Page.
The soy bean as a seed crop 3
Time of harvesting 3
Methods of harvesting 4
Methods of curing and handling 5
Thrashing 6
Special bean harvesters 7
Soy-bean straw 7
Storage of seed 8

THE SOY BEAN AS A SEED CROP.

THE character of growth, the uniform maturing habit, and the heavy seed yields of the soy bean contribute to the ease of harvesting and recommend the plant for seed production. The many disadvantages which attend the harvesting of cowpeas for seed are not common to the soy bean. When grown for grain alone the shattering of the pods of the soy bean is a serious fault, and inexperienced growers are likely to sustain a heavy loss of seed through lack of knowledge and improper handling of the soy-bean plant.

All soy beans are strictly determinate as to growth—that is, the plants reach a definite size, according to variety and environment, and then mature and die. Nearly all varieties shatter their seed somewhat, especially during changeable weather, if not harvested at the proper stage of maturity. Some varieties, like the Guelph or Medium Green, shatter inordinately, while others, such as the Peking, scarcely at all. Special attention, therefore, is required when the plants approach maturity to prevent serious losses from the shattering of the pods.

TIME OF HARVESTING.

When the soy-bean plant is near maturity, the leaves begin to turn yellow and drop; and before all of the pods are mature the leaves, except in a few varieties, have all fallen off. In general, the best time to harvest, except where special bean harvesters are used, is when about three-fourths of the leaves have fallen and most of the pods have turned color. If cut at an earlier stage the plants are difficult to cure properly, and the yield will be lessened materially on account of the immature grain. On the other hand, if the plants are allowed to become too ripe the pods will shatter before being cut, and much seed will be lost. When special harvesters are used to gather the seed, the plants must reach full maturity to obtain the best results.

The stage of maturity to which the plants should be allowed to grow varies also with regard to season and variety. In a hot, dry fall the plants should be cut at an earlier stage than in a cool, moist

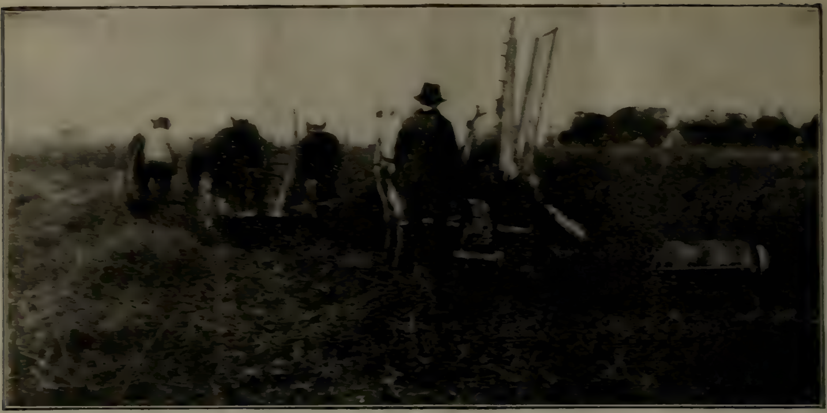

FIG. 1.—Mowing machine with side-delivery attachment.

fall. Some few varieties, however, can be left with little or no loss of seed until time of maturity in any season.

METHODS OF HARVESTING.

Various methods of harvesting the crop are used in different sections where the soy bean is grown largely for seed production. When the cutting is done with a mowing machine, it is well to have a side-delivery attachment (fig. 1), in order that the horses will not need to trample on the swath of cut beans. If cut with a mower without such an attachment, however, the plants should be removed at every round out of the way of the team, for if trampled upon many of the seeds will be shelled out and wasted.

The self-rake reaper (fig. 2) has given very satisfactory results, as the plants are placed in bunches out of the way of the machine and team.

The self-binder can be used to good advantage with the taller growing varieties of beans if the plants are not too coarse. This

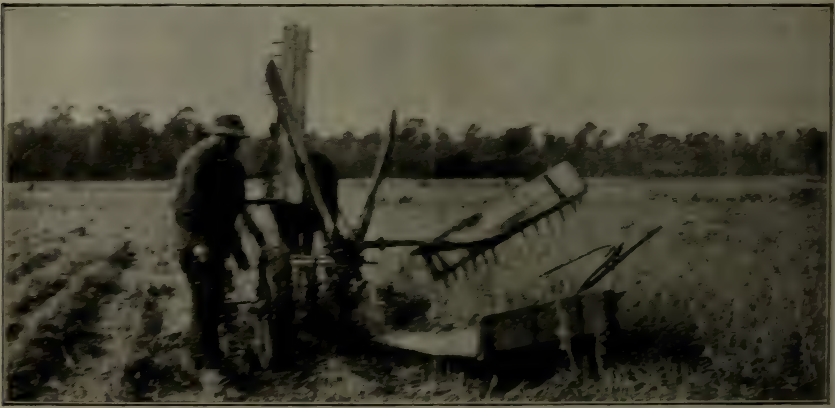

FIG. 2.—Self-rake reaper used in cutting soy beans for seed.

method of harvesting is coming rapidly into favor in many sections. For the best results with this machine the plants should be cut while some of the leaves are still retained, as the plants will cut more easily and no loss will result from shattering.

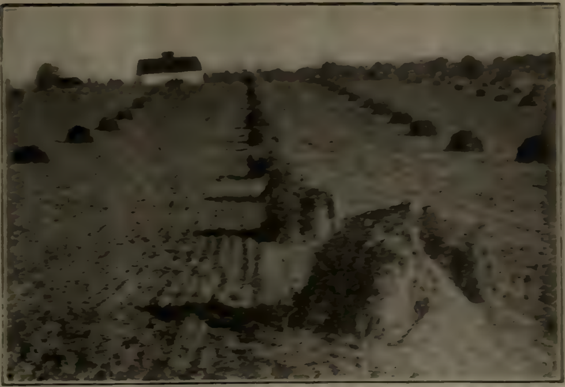

FIG. 3.—Soy beans cut for seed with a binder and the shocks set in rows so that wheat can be sown without waiting to remove the beans from the field.

The bean harvester which is used to a slight extent in a few Northern States is mounted on wheels like a riding cultivator. It has knives that can be adjusted to run just beneath the surface of the ground, cutting the plant where it is soft. This machine will cut two rows at a time and place both in a windrow for curing and convenient for handling. To do good work, the cutting knives must be kept sharp; otherwise the plants will be pulled out by the roots instead of being cut off.

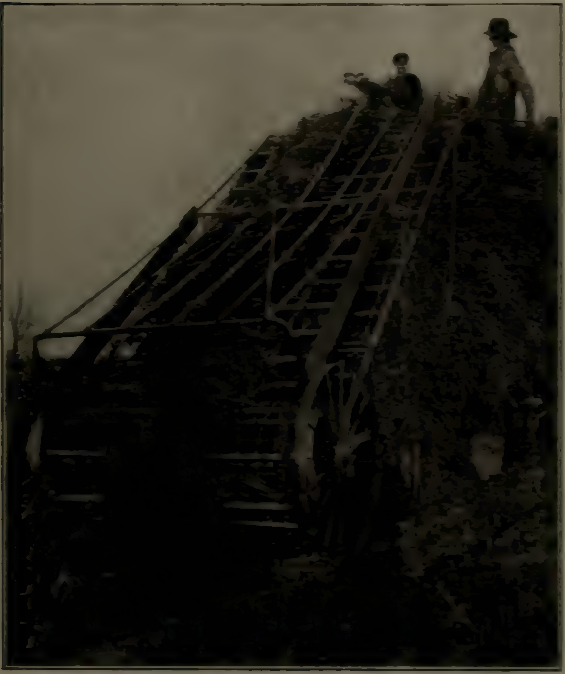

FIG. 4.—A single-drum web loader, commonly used for haying. This will load the soy beans rapidly and with less loss of seed than would result in hand gathering.

Small areas may be cut with a scythe, corn knife or sickle. In some sections comparatively large acreages are cut in this manner.

METHODS OF CURING AND HANDLING.

When cut with a mowing machine with an attachment or with a self-rake reaper, the beans may be raked in

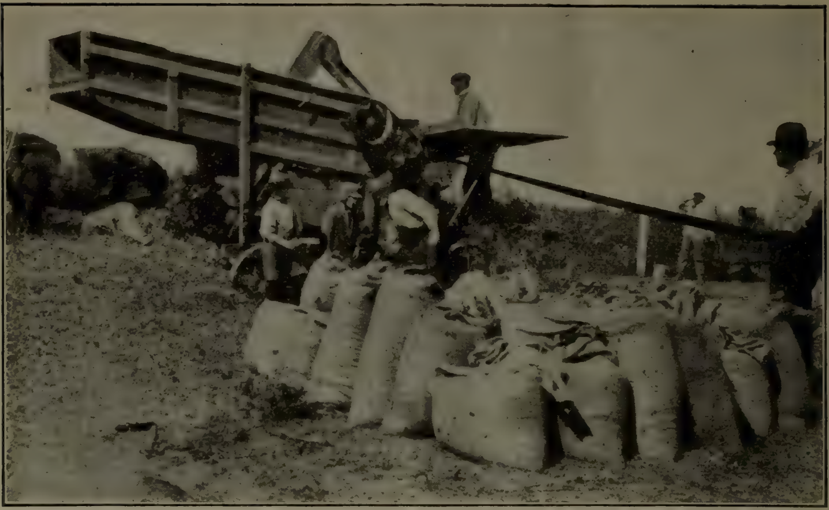

FIG. 5.—Thrashing soy beans from the field in eastern North Carolina with an ordinary gasoline thrashing outfit.

small piles or placed in small shocks. These piles or shocks should be left for four or five days in good drying weather, or until the grain is found to be fairly dry in the pods. Wet weather does not injure the crop seriously provided the plants are not allowed to rest on the ground long at a time. If rain occurs, the piles should be watched carefully and turned frequently.

Where a binder is used the bound bundles should be shocked 8 or 10 to a shock (fig. 3) and allowed to remain until thoroughly dry.

Hay caps are not necessary when the piles or bundles are shocked properly. They may remain in the field until thrashing time, or if thoroughly dry they may be housed and thrashed later.

The cured plants are ordinarily gathered from the field by hand, but the web loader (fig. 4) commonly used for haying will do the work more rapidly and with less loss of seed than the hand methods.

THRASHING.

The ordinary grain separator (fig. 5) can be adjusted to thrash any beans successfully, but as equipped for small grains a large percentage of cracked beans will result. The chief cause of split beans is the high speed of the cylinder, which should be reduced at least one-half, but the speed of the fans and other parts of the separator should be maintained. This may be accomplished by doubling the size of both cylinder pulleys. In some cases a special set of thin concaves is used, while in other instances some of the concaves are removed. Good judgment on the part of the thrasherman will enable him to adjust the ordinary separator so that the beans may be thrashed with little splitting. Some manufacturers have special pea and bean hulling attachments for grain separators, which are said to do very satisfactory work. These attachments may be added to the ordinary separator at a small cost.

Special pea and bean separators of different sizes are now on the market. These types of machines do clean hulling and split practically none of the beans. Undoubtedly such separators are more satisfactory and economical where a considerable acreage of beans is grown. In sections where there is extensive seed production, investment in such a machine by the community would be profitable.

Soy beans, if thoroughly dry, can easily be thrashed with a flail. If one has only a small acreage—an acre or so—this method is practicable and economical.

In a few sections a corn shredder has been used to advantage. If properly cured and dried, the beans shell out very readily with this machine.

SPECIAL BEAN HARVESTERS.

The harvesting of seed from the mature standing vines by means of patented bean harvesters, of which there are several types, is rapidly gaining in popularity in sections where the soy bean is grown rather extensively. The commonest type is a 2-wheeled, boxlike machine and is drawn by two horses (fig. 6). As the machine passes over the row of plants, four sets of rapidly revolving arms shatter the beans from the pods into the body of the harvester. As the machine moves up the row, the seed is gradually raked by a man to the rear of the box. To secure the best results the rows should be ridged, though a recently patented machine is suitable either for ridged or level rows. Under favorable conditions, two men with a team can harvest 1 acre in two hours by this method. Although there is some loss of beans, it is more than compensated by the saving of time and labor.

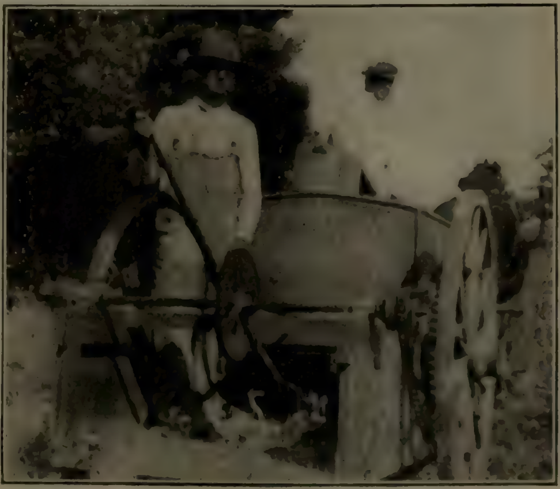

FIG. 6.—A special bean harvester used in gathering the soy-bean seed from the standing mature plants.

SOY-BEAN STRAW.

The straw obtained from thrashing the soy bean for seed is a valuable feed for all kinds of stock. In

FIG. 7.—Baling soy-bean straw direct from the thrasher.

many sections the straw is baled at the time of thrashing (fig. 7) and sold in the immediate locality to liverymen, dairymen, and stock feeders.

STORAGE OF SEED.

As soy-bean seed spoils rather easily if not properly handled, care should be exercised in curing and storing. After the beans are thrashed they should be watched carefully to avoid heating and molding. When thoroughly dry there is no such danger. The best plan, perhaps, is to spread the seeds out on a floor immediately after thrashing and shovel them over from time to time until they are thoroughly dry. After this they may be safely put into sacks or bins. The storeroom should be dry and have a free circulation of air. Soy-bean seed loses its viability rather rapidly, and it is not safe to hold seed for planting purposes more than two seasons. The seeds of the soy bean, unlike those of the cowpea, are rarely attacked by weevils or other grain insects.

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RASPBERRY CULTURE

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UNITED STATES DEPARTMENT OF AGRICULTURE

See revised edition indexed in covers

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WM. A. TAYLOR, Chief

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THE RASPBERRY is grown not only in small plantations for the home and local market, but in some sections as the principal commercial crop. In these localities the raising of raspberries has become highly specialized, and methods of growing which are peculiar to this industry are employed.

This bulletin furnishes information as to the best methods of raising raspberries, and particularly considers practices which differ from those used with other bush fruits. Varieties are listed, characterizations of the leading sorts and their adaptations are made, and the autumn-fruiting sorts are discussed. The varieties liked best for canning and preserving are listed and directions for their utilization given.

The directions given are based on practices which have proved highly successful in different sections. They may require modification in some particulars to meet local conditions, but they will be of value to those whose experience in raspberry culture is limited.

RASPBERRY CULTURE.

CONTENTS.

	Page.
Types of raspberries	3
Extent and distribution of raspberry growing	4
Location of a plantation	5
Site of a plantation	6
Preparing the land	7
Planting	7
Moisture supply in the soil	14
Intercropping	15
Tillage	15
Maintenance of fertility	16
Systems of training and pruning	17
Winter protection	30
Duration of a plantation	32
Harvesting	33
Yields	34
Diseases and insects	35
Propagation	35
Varieties	36
Uses	42

TYPES OF RASPBERRIES.

THREE types of raspberries (red, black, and purple) are grown extensively in the United States. Red raspberries bear red fruit, have erect canes, and usually are propagated by the suckers which come from the roots of the parent plant. Some of the varieties under cultivation come from the European and the rest from the American wild red raspberry. Among the leading red varieties are the Cuthbert, Ranere, and King.

Black raspberries, or blackcaps, bear black fruit, have arched canes which root at the tips in the autumn, and are propagated by the plants formed at the tips. All black varieties come from the American black raspberry, which grows wild in the eastern part of the United States. Under cultivation they are not, however, as hardy as some of the red varieties which come from the American wild red raspberries. The Gregg, Ohio, and Cumberland are important commercial sorts of the black type.

The varieties under cultivation bearing purple-colored fruit are hybrids between the red and black raspberries and have canes that arch and root at the tips, as do the black raspberries. The Columbian and Cardinal are leading purple sorts.

Occasionally plants appear of both the red and black types which bear yellow fruit, but the yellow varieties in cultivation belong to the red-fruited type. The Golden Queen is the leading yellow-fruited variety. It is rarely grown for the general market, but is adapted to home gardens and to special markets.

Figures 1 and 2 show the differences between the fruit clusters of the red and black varieties.

EXTENT AND DISTRIBUTION OF RASPBERRY GROWING.

In 1909, according to the reports of the Thirteenth Census, there were 48,668 acres of raspberries and Logan[1] dewberries in the United States. As Logan dewberries are grown chiefly in Oregon and California, the total area devoted to raspberries is not very different from these figures. Table I gives the distribution of raspberries in 1909, by States.

TABLE I.—*Acreage devoted to raspberries and Logan dewberries in the United States in 1909, by States.*

Geographic division and State.	Acreage.
New England States:	
Maine	127
New Hampshire	85
Vermont	80
Massachusetts	388
Rhode Island	34
Connecticut	289
Middle Atlantic States:	
New York	11,057
New Jersey	1,744
Pennsylvania	2,594
East North-Central States:	
Ohio	3,869
Indiana	1,412
Illinois	1,945
Michigan	8,786
Wisconsin	964
West North-Central States:	
Minnesota	1,388
Iowa	1,573
Missouri	1,331
North Dakota	85
South Dakota	66
Nebraska	247
Kansas	713
South Atlantic States:	
Delaware	223
Maryland	846
Virginia	276
District of Columbia	(1)
West Virginia	847
South Atlantic States—Continued.	
North Carolina	40
South Carolina	2
Georgia	29
Florida	(1)
East South-Central States:	
Kentucky	564
Tennessee	253
Alabama	11
Mississippi	5
West South-Central States:	
Arkansas	123
Louisiana	1
Oklahoma	85
Texas	104
Mountain States:	
Montana	113
Idaho	496
Wyoming	14
Colorado	801
New Mexico	12
Arizona	1
Utah	374
Nevada	9
Pacific States:	
Washington	1,210
Oregon	1,460
California	1,992
United States	48,668

(1) Less than 1 acre.

It should be noted that the cultivation of the raspberry is limited very largely to the northern part of the United States, chiefly to those sections in which the wild raspberries grow most abundantly.

The red-raspberry sections, from which extensive shipments are made, are located in southern New Jersey, in the Hudson River valley, in western New York, in western Michigan, in the Puyallup Valley of Washington, and about Sebastopol, Cal. The acreage in southern New Jersey and in the Puyallup Valley of Washington has been increasing rapidly in recent years and is now much larger than the census figures indicate.

Black raspberries are grown for commercial shipment in western New York, in western Michigan, in the sections about Wathena,

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[1] The Logan dewberry here referred to is the fruit commonly known as "loganberry." Recent investigations make it reasonably certain that this fruit is a straight seedling of the Pacific coast dewberry (*Rubus vitifolius* or *R. ursinus*) rather than a hybrid possessing unique characters.

Kans., and Hagerstown, Md., and to a less extent in other places. There are few plantations in the Southern States or on the Pacific coast.

The purple varieties are grown extensively in western New York only, although for local market and home use their range is about the same as that of the blackcap.

LOCATION OF A PLANTATION.

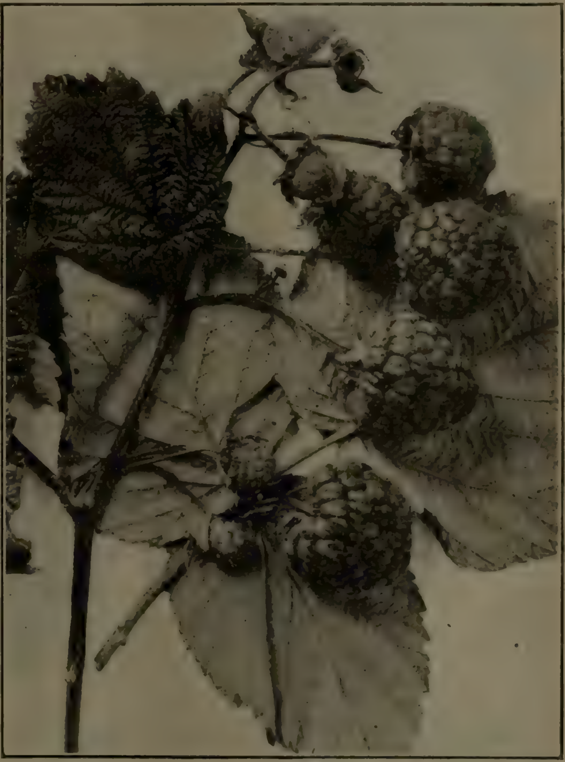

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FIG. 1.—A fruit cluster of the Loudon (red) raspberry.

Particular attention should be given to the locality in which the raspberry plantation is to be established.

The hot summers of the South are not favorable to the production of this fruit, which is a native of States having a cool climate. There are few plantations south of Virginia, Tennessee, and Missouri, and even the warmer parts of Virginia and Tennessee are not well adapted to raspberry growing. The black and purple varieties have not proved to be well adapted to conditions in the Pacific Coast States, although red raspberries are grown very successfully in that part of the country. In most of the Great Plains area and in parts of the Mountain States of the West the winters are too severe or the summers too hot and dry for raspberry growing.

The raspberry plantation should be located near a good market or good shipping point if it is to be most profitable. The roads to that market or shipping point should be such that the berries will not be injured when hauled over them. If the fruit is to be shipped long distances it is essential that quick transportation and refrigerator-car service be available.

SITE OF A PLANTATION.

Three important factors which should be considered in the selection of a site are the soil type, the moisture supply, and the air drainage.

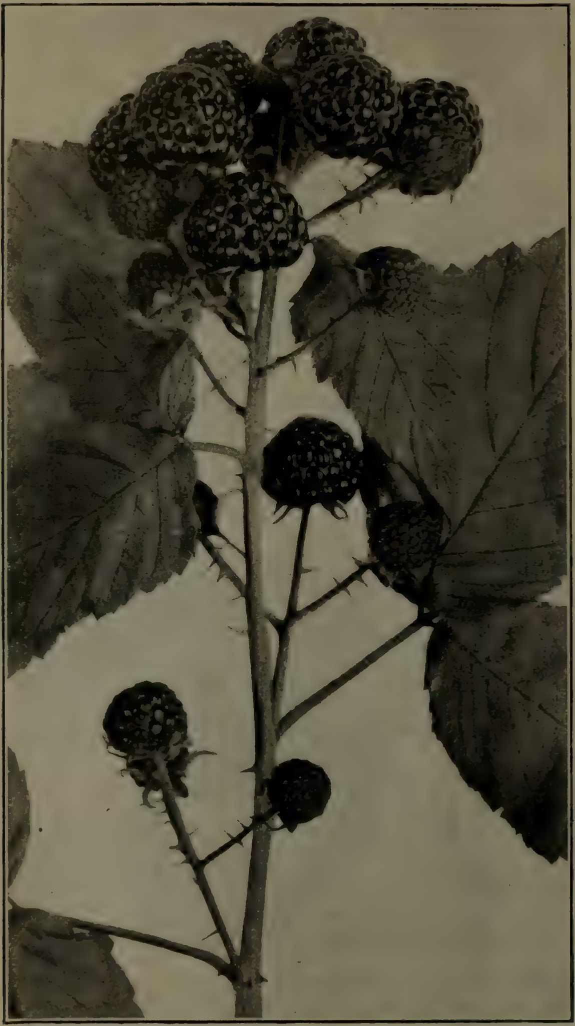

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FIG. 2.—A fruit cluster of the Cumberland (black) raspberry. Contrast the stiff, prickly fruit stems here shown with the slender, drooping stems of the red variety shown in figure 1.

Although the raspberry will succeed on a wide range of soil types provided suitable moisture conditions prevail, the best results will be secured only by studying the peculiar requirements of the different varieties. A fine, deep, sandy loam is perhaps the most desirable soil for growing raspberries, because it is managed so easily. Equally good yields of some varieties will be secured on clay and on sandy soils if they are well managed. In general, however, though the black raspberries seem to do best on sandy soils, they are grown extensively and succeed well on clay soils. Among the red raspberries the Ranere does best on sandy types, but the June prefers a clay soil. Other varieties, such as the Cuthbert and King, succeed on a wide range of soil types. Where the soil requirements of varieties are known, they are indicated in the characterizations given on later pages of this bulletin.

The most important, perhaps, of all the factors entering into the growing of raspberries is the moisture supply, and where there is the possibility of a choice, the soil which will furnish an ample supply of moisture at all times should be chosen. At no time, however, should there be wet places in the plantation. Thorough drainage as well as a full supply of moisture is essential.

Another important factor is air drainage. Cold air settles to the lower levels, and plantations situated on land elevated above the surrounding fields will not be as subject to the extreme cold of winter as plantations on the lower levels. Winter injury to the canes may often be avoided by choosing a site higher than the surrounding country. Furthermore, plantations on the higher elevations are not as subject to frost injury in late spring as those not so favorably located.

In the Southern States, a fourth factor in the selection of a site is of some importance. If raspberries are to be grown in those States, a northern or northeastern slope is preferred for the plantation, as humus and moisture are retained better in fields on such slopes than on southern slopes.

For home gardens, the chicken yard is frequently a desirable place for the raspberry patch. Poultry keep down weeds and enrich the soil, and do not often injure the berries.

PREPARING THE LAND.

The same thorough preparation of the soil should be given for a raspberry plantation as for corn or similar crops. For the best results the plants should never be set in a field which has just been in sod, but should follow some hoed crop. Land which produced a crop of potatoes the previous year and which has later been plowed and thoroughly pulverized is in the best physical condition for setting the plants, and any field on which crops have been grown which leave the soil in a similar condition is prepared properly for raspberries.

PLANTING.

The time of planting raspberries varies in different parts of the United States, according to the local conditions. In general, however, the plants should be set in early spring in the eastern part of the United States, but on the Pacific coast they should be set during the rainy season, whenever it is possible to do the work.

Because better plants of the black and purple varieties can be secured in the spring, that is the best season for setting them. Red raspberries, however, may be set in the autumn with good success in sections where the winters are mild or where there is a good covering of snow to protect the plants. Some of the advantages of autumn planting in sections where this is possible are the following:

(1) There is usually a much longer season in which the planting conditions are favorable than in the spring.

(2) During the winter the plants become thoroughly established in the soil, and they start growth quickly in the spring.

(3) In the autumn the leader buds from which the new canes develop are dormant and are not broken easily. By spring, however, they have grown to a considerable length, often several inches, and then are broken very easily in planting. Unless the root is vigorous, such plants may not develop new shoots. Figure 3 shows the leader buds at the base of the cane in a dormant condition, and figure 4 shows the buds after they have developed into shoots several inches long, which are broken very easily.

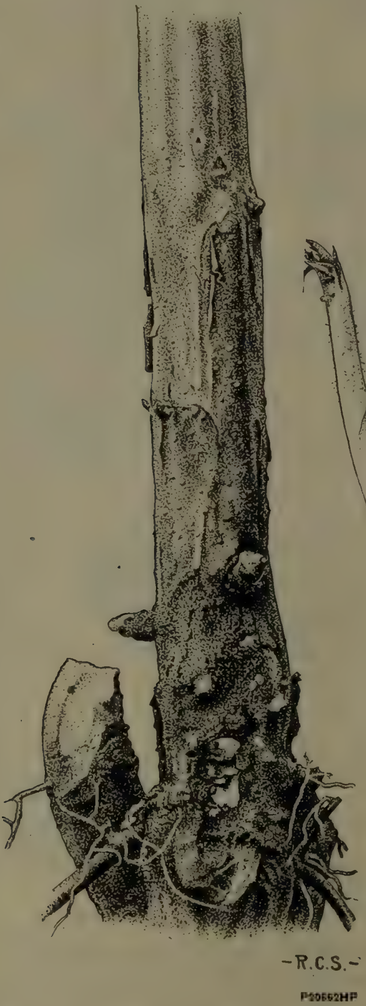

FIG. 3.—Lower part of a raspberry cane, showing dormant leader buds from which strong, vigorous shoots will grow in the early summer. (Drawing from a photograph taken February 9.)

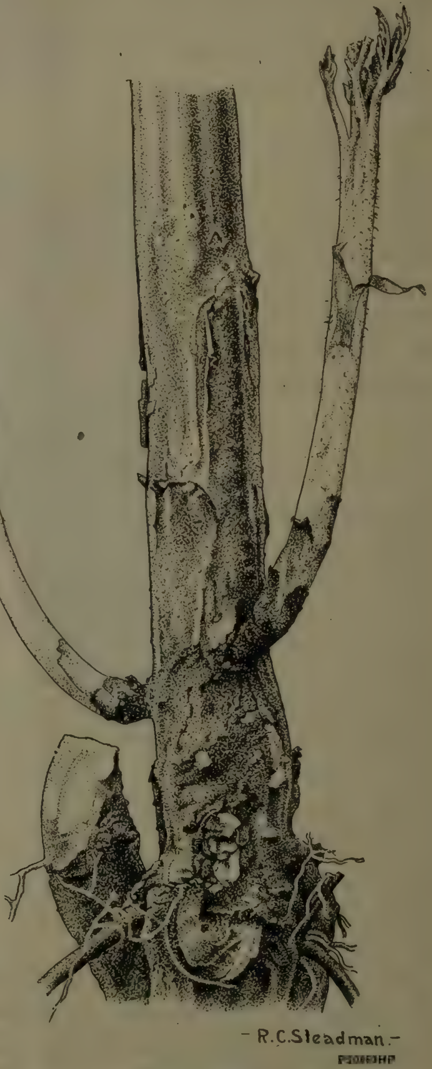

FIG. 4.—Lower part of the raspberry cane illustrated in figure 3, showing the new canes that have started growth from the leader buds. (Drawing from a photograph taken on March 7.)

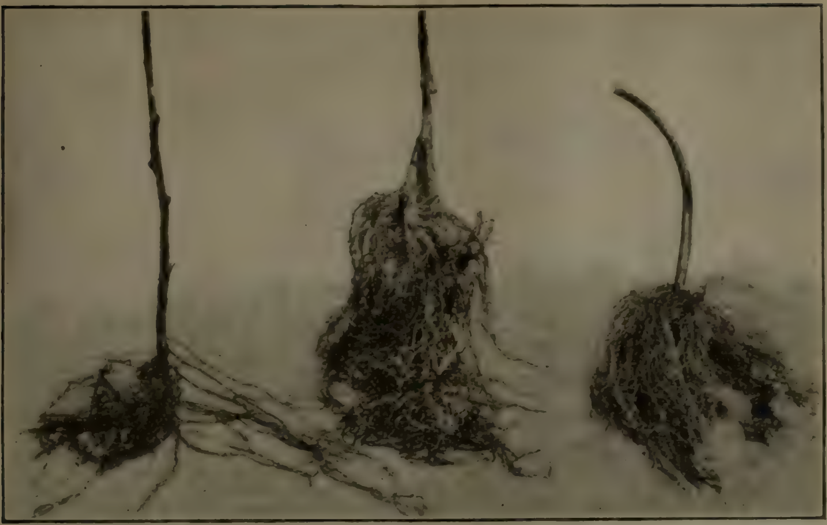

FIG. 5.—Sample raspberry plants good for setting: Ranere (red) at the left, Columbian (purple) in the center, and Cumberland (black) at the right.

Occasionally when growers wish to set a new plantation they wait a month after growth starts in the spring and use the suckers that come up during that month in their established plantation. If the season is favorable, this practice may prove satisfactory. If, however, a drought occurs soon after, the young plants will suffer severely. Only in sections where the climate is favorable is this practice to be recommended.

SECURING AND HANDLING NURSERY STOCK.

Good nursery plants of the different types of raspberries are shown in figure 5. It must be remembered, however, that the root systems of nursery plants of the different varieties vary greatly, and what constitutes a good nursery plant of one variety may be a poor plant of another variety. Thus the Royal, a purple variety, rarely makes as large a nursery plant as does the Columbian, shown in figure 5. Consequently a good nursery plant of the Royal would not be considered a good plant of the Columbian.

Figure 6 shows a bundle of plants of the red raspberry as it was received from the nursery. In case the plants are not to be set immediately, they should be heeled in: that is, a trench should be dug and the roots placed in it and covered with moist soil. In order to work the soil thoroughly about the roots of each plant it will be necessary to open the bundles and spread the plants along the trench, as shown in figure 7. Sometimes it is desirable to wet the roots, or, if they are very dry, to soak them for a few hours before heeling in the plants.

Just before setting it is well to dip the roots of the plants in a puddle made of clay and water or cow manure and water. The roots are thereby partially protected from the wind and sun.

Plants affected with crown-gall should not be set. This disease can be recognized by the knots and swellings which appear on the roots and about the crown. Such diseased plants are very much less productive than healthy stock.

SYSTEMS OF CULTURE.

Three systems of culture are used in growing raspberries, the hill, the linear, and the hedge systems. The term "hill system" is restricted to that method of tillage in which the horse cultivator is used on all sides of each plant. When the cultivator is run in only one direction and only the plants originally set are allowed to fruit, the term "linear system" is used. If some of the suckers which come

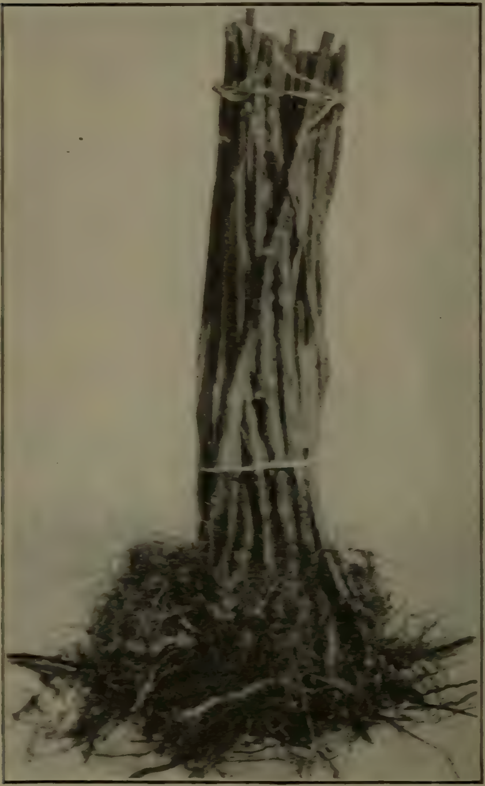

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FIG. 6.—A bundle of 27 good plants of the Ranere raspberry as received from the nursery. When such plants can not be set immediately, they should be "heeled in."

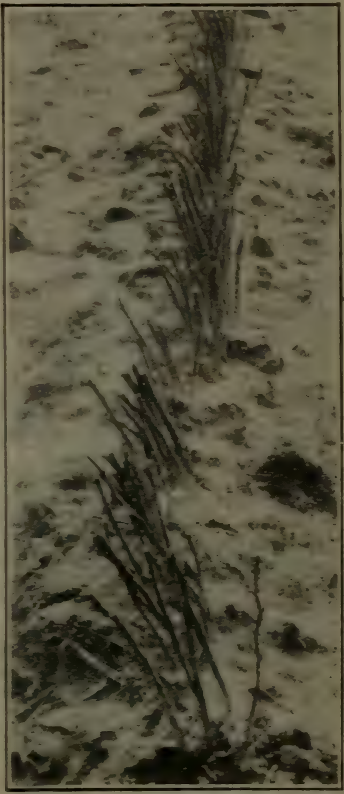

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FIG. 7.—Plants of the Cuthbert raspberry as received from the nursery, "heeled in," awaiting favorable opportunity to plant.

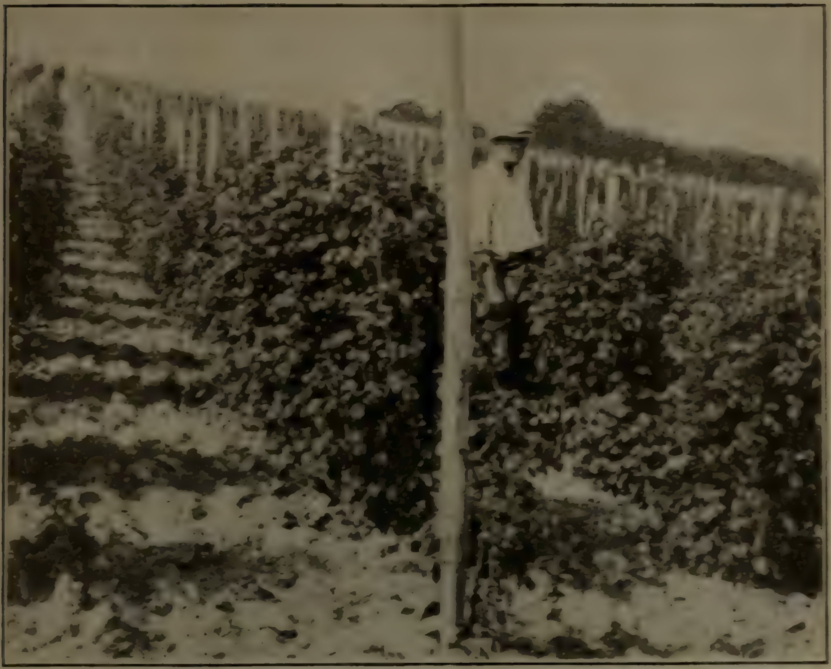

FIG. 8.—Perfection red raspberries 1 year old, planted in accordance with the hill system. (Photographed at Milton, N. Y., June 18, 1915.)

from the roots of red raspberries are left to form a solid row and the cultivator is run in one direction only, the term "hedge system" is employed.

The distance between the rows in each of these systems should be determined by economy in the cost of cultivation and in the use of land. Where the area of land available for planting is not limited, usually it will be found most desirable to make the spaces between the rows wide enough to allow the use of 2-horse implements in cultivation. Where the area of land is limited, the rows may be placed closer together and 1-horse implements used.

PLANTING DISTANCES.

Under the hill system of culture the plants usually are set about 5 feet apart each way. This, however, allows the use of 1-horse cultivators only. Figures 8 and 9 show fields planted according to the hill system. This is used to some extent in New York and other States in raising red raspberries. It has the advantage of requiring less handwork in keeping out grass and weeds, as the cultivator can be run in both directions; and the berries can be more easily harvested from fields under this system.

If the hedge or linear system is used, the horse cultivator can be run in one direction only and more hand hoeing is necessary. Under these systems the red varieties usually should be set from 2 to 3 feet apart in rows which are 6 to 8 feet distant. In the eastern United States 6 feet is the most common and desirable distance between the rows for the shorter caned varieties, such as the Ruby and Marlboro, and 7 and 8 feet for the tall-caned varieties, like the Cuthbert. To use two horses in a plantation the rows must be at least 8 feet apart. In the Pacific Northwest, where the canes grow very tall, the planting distance for red raspberries is usually 2½ by 7 or 8 feet. In parts of Colorado and other States where irrigation and winter protection are necessary, the plants are usually set in rows which are 7 feet apart.

Black raspberries are nearly always grown under the linear system, and in the United States east of the Rocky Mountains they should be planted in rows 8 feet distant and 3 or 4 feet apart in the row. In Oregon and Washington they should be planted in rows 7 or 8 feet distant and from 3 to 6 feet apart in the row, depending upon the vigor of the growth in the particular locality.

The purple varieties also are grown under the linear system and should be planted 4 or 5 feet apart in rows which are 7 or 8 feet distant. The Columbian and other purple varieties of equal vigor should be at least 5 feet apart in the row, but the Royal may be set 4 feet apart.

If the plants are checked in both directions when set in accordance with either the hedge or linear system and are 3 or 4 feet apart in the row, it is possible to run a 1-horse cultivator both ways for the first year. This will save much work and reduce the first year's expense.

In some sections, two plants of red raspberries are set together. This insures the grower against misses, and a larger crop is secured when the plantation is 1 year old. It will cost nearly $20 more per acre to buy and set the extra plants, but in some sections the additional yield will make it profitable. However, if care is taken in setting, one plant in each place is usually sufficient.

SETTING THE PLANTS.

Before planting, the tops of the plants of all types should be cut back to 6 inches or less in height. To make it easy to handle the plants and to indicate the rows after setting, 4 to 6 inches of the cane should be left. If a garden patch is being planted, it is better to cut the canes back to within a few inches of the leader buds. The plants should be set slightly deeper than they formerly grew. Sometimes it is well to set red raspberries as much as 3 inches deeper than they grew, in order to protect them from drought. Black and purple raspberry plants should be set not more than an inch or two deeper than they formerly stood, as there is danger of smothering the tips.

Figures 10 and 11 illustrate a common and inexpensive method of setting the plants. The rows have been marked out previously and plants have been dropped every 3 feet along the row. The spade is thrust into the ground, the handle pushed forward, and the root placed in the space thus opened, as shown in figure 10. The spade is next withdrawn and the earth firmed about the roots, as shown in

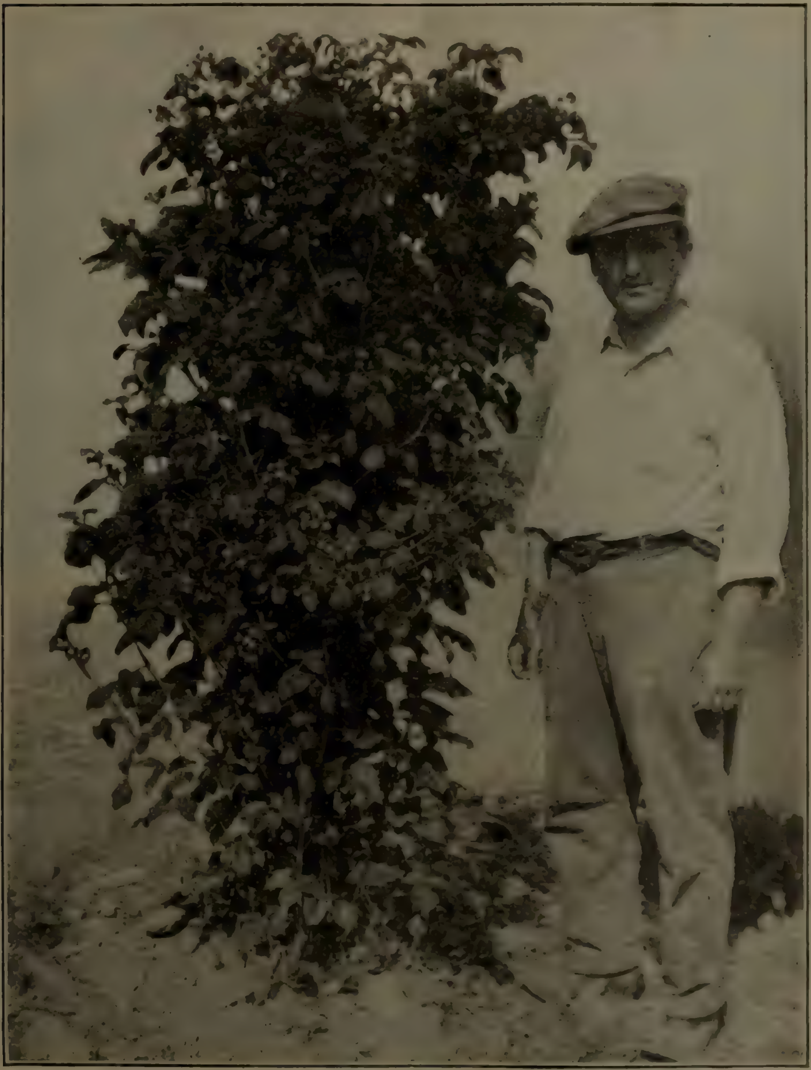
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Fig. 9.—A perfection red raspberry planted in accordance with the hill system. This plant has seven bearing canes, which are tied to a single stake. (Photographed at Milton, N. Y., June 18, 1915.)

figure 11. Plants should not be dropped much ahead of those who are setting them, however, as exposure to the sun and wind weakens the roots.

MOISTURE SUPPLY IN THE SOIL.

From the time raspberry plants are set, they need an ample supply of moisture, and they are affected more quickly and seriously when it is deficient than most other fruit plants. In the sections where the highest average yields of red raspberries are obtained, often 6,000 quarts of fruit per acre are secured. The average for the whole country, however, is not more than 1,500 quarts, and this difference is due almost wholly to a difference in the moisture supply. In the sections referred to as giving the highest yields, a deep soil furnishes a uniform and ample supply of moisture at all times. To secure the best results, therefore, the grower should, by tillage and by supplying humus, maintain a uniform and ample moisture content in his soil, not only during the growing and ripening of the fruit but also while the canes are developing. Some growers make it a regular practice each year to mulch their fields to a depth of several inches with straw, leaves, or green hay. When this practice is followed, the cost is great but the moisture supply is retained well.

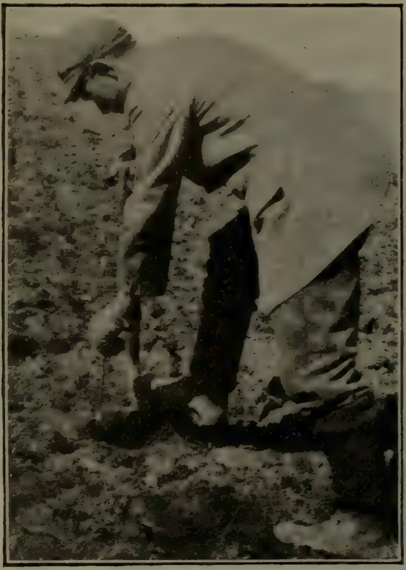

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FIG. 10.—Setting raspberries. The shovel or spade is thrust into the soil and forced forward. The plant is put in the opening thus made and the shovel is then withdrawn. Earth is later firmed about the roots, as shown in figure 11. (Photographed at Putney, Vt., April 23.)

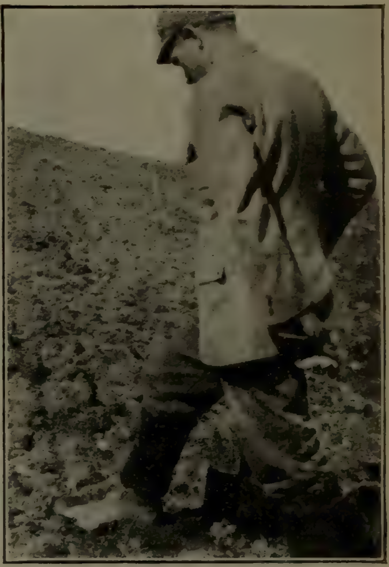

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FIG. 11.—Firming the earth about the roots of the raspberry plant shown in figure 10. In this field not more than 2 or 3 out of the 10,000 plants set failed to grow. Figures 10 and 11 illustrate a common and inexpensive method of setting raspberry plants.

In semiarid and arid regions where irrigation is practiced, the fruiting season is longer than in most humid or nonirrigated sections. The use of irrigation in the Eastern States also has extended the picking season and made the plants thriftier. Larger yields of fruit of the Ranere raspberry in the summer and fall have followed the irrigation of that variety and made it profitable in some sections of the East.

In the semiarid and arid regions of the Pacific coast, irrigation should begin almost as soon after the rainy season as is necessary for garden crops and should be continued at least until after the picking season is over. The frequency of irrigation will depend upon the local climate, the soil type, and the management of the soil. In southern California, the plantations should be irrigated as often as every week during the fruiting season, and about once in two or three weeks during the rest of the dry season. A cultivator should be run between the rows after each application of water. When this is done the irrigation need not be so frequent, and the soil will be kept in better condition than without such tillage. Under such treatment the Surprise red raspberry will produce not only a good second crop of fruit during the late summer or early fall in some parts of California, but also some fruit almost continuously from the first picking in the spring until late autumn. In arid and semiarid sections other than California such frequent irrigation is not often used; its frequency is determined by local conditions.

In the humid sections of the Eastern States, irrigation should be used chiefly or entirely during the growth and ripening of the fruit and will pay only when an ample moisture supply can not be maintained by tillage. As the raspberry ripens its crop during the summer when droughts are likely to occur, some growers have found irrigation profitable.

INTERCROPPING.

In order to reduce the cost of intensive cultivation of a raspberry plantation during the first year after setting, other crops that need cultivation during the spring and early summer months may be grown between the rows. Among the crops best suited to this use are the tomato, cabbage, cauliflower, bean, pea, summer squash, and potato. Grain crops should not be used, as they are not cultivated and will take moisture and plant food needed by the raspberry plants. The second season no other crop should be grown, as the raspberry roots should occupy all the ground.

TILLAGE.

Tillage in raspberry fields must be thorough and more regular than for most other crops. If grass and weeds get a start, it is very difficult to clean the rows. Not only will it prove costly to clean them, but grass and weeds take the needed moisture and interfere with the development of new canes. If grass is allowed to make a sod in a field trained to the wide hedge system, it is usually cheaper to set out a new field than to clean out the sod.

Tillage should be thorough and regular in order to conserve moisture. Except in rainy weather, a cultivator or harrow should be used at least once each week up to picking time. Some growers consider it profitable to use it as often as twice each week, and this is sometimes necessary during periods of extended drought. The cultivation should stir the soil to a depth of 2 to 3 inches only, as part of the raspberry roots are shallow. Many growers shorten the cultivator or harrow teeth which run next to the plants, so as to disturb the young feeding roots near the surface as little as possible.

During the harvesting season the berries need an additional supply of moisture, and ordinarily the cultivation should be continued. Many growers cultivate after each picking, loosening the soil packed down by the pickers. If too much dust is carried to the fruit it may be necessary to cultivate only occasionally during the picking season. Also if no trellis or stakes are used and if the canes bend over under a crop of fruit it will be impossible to use a cultivator without knocking off too much fruit.

Later tillage is for the purpose of keeping down weeds and grasses. The fields should be free of weeds during the winter season, as many kinds start quickly in the spring and are difficult to destroy after the soil is in condition to work. Autumn tillage, however, tends to develop new growth, which is tender and somewhat more subject to winter injury than the older growth. Autumn tillage, therefore, should be avoided as much as possible where there is danger from severe winters.

MAINTENANCE OF FERTILITY.

The use of fertilizers in raspberry plantations is governed by the same principles that apply to their use with other fruits. As soils vary in the quantity and availability of the plant food they contain, the fertilizer problem is a local one which each grower must solve for himself. By using varying amounts of the different elements of plant food on different plats and keeping a record of the yields, each grower can determine readily what kinds and quantities of fertilizer to apply.

Good management, however, will insure a large amount of humus in the soil at all times. It is especially desirable that the humus supply be ample when the plantation is first set out. It is much easier and cheaper to furnish the humus by means of cover crops and stable manure before the plantation is set than afterwards when the plants are growing. Moreover, by such extra care before setting it is possible to secure a fair crop of fruit the second season. Because it costs so much to care for a plantation for a year it will pay well to have the soil in a high state of fertility before the plants are set, so that the plantation may be brought into bearing a year sooner than would be possible otherwise.

In many sections no fertilizers are used on bearing plantations. In the older raspberry sections, however, some commercial fertilizer and stable manure are used, and it is considered profitable to use them. Stable manure, however, usually has given the best results and experiments have shown that, where obtainable, it furnishes the best means of enriching the soils on which the experiments have been tried. Stable manure not only furnishes some plant food but supplies large quantities of humus. If an annual application of about 10 tons per acre is made, the humus supply should be maintained, and with proper treatment in other ways the field should be kept at a high state of productiveness. Some soils and some sections will need a larger quantity and some less than 10 tons per acre. A heavier application, however, should not be made unless it has been found by actual trial to be desirable, as it is possible to stimulate the growth of canes and leaves to such an extent as to reduce productiveness.

Cover crops may be used to maintain the humus supply. Oats seeded at the rate of 3 bushels per acre in late summer should give a dense stand of material to turn under before winter, or they may be left to serve as a covering during the winter and plowed under in the spring. Cowpeas, vetch, the various clovers, and other crops also may be used in the raspberry plantation. Care must be taken in growing the vetch and clovers, as they live through the winter and it may prove costly to eradicate them. However, if they are drilled in between the rows and turned under before they become too rank in the spring, little trouble should be experienced.

SYSTEMS OF TRAINING AND PRUNING.

The best system of training and pruning the different types of raspberries depends largely upon their manner of growth. All types send up shoots called "turions" from the leader buds which usually are formed at the base of the old canes, as shown in figures 3 and 4. Sometimes only one such bud is produced on each cane, but usually at least two are formed, and sometimes three or more appear. Thus, if two canes grew the first year after planting and each produced two buds, four canes would appear the second year, eight canes would be formed the third year, and by the fourth year there would be 16 canes. However, some of the buds do not start and many of those that do start make weak canes, so that when plants are in bearing about the same number of strong canes are produced the first year after the plantation comes into full bearing as during each of the following years.

The new shoots of all types of raspberries complete their development in size the first season. The second season small side branches are sent out on which the fruit is borne. As soon as the berries ripen the cane dies and is cut out. Thus the canes are biennial, that is, they live for part of two years; and the roots are perennial, living for many years. A few varieties of red raspberries, among which is the Ranere, bear fruit on the tips of the new canes in the summer and autumn of their first year of growth. Such tips die back, and the parts of the cane which have not fruited bear the following summer.

In addition to producing canes from the leader buds, red raspberries send up shoots called "suckers" from their roots (fig. 12), but the black and purple varieties do not send up suckers. Some varieties of red raspberries produce suckers in large numbers; others produce few. Deep plowing or cultivating may cut the roots of the red raspberry and cause an increase in the production of suckers. Therefore, if some system of training were not used a red raspberry field would soon become a dense thicket of canes, each competing with others for food, moisture, and light, and the berries could be picked only with difficulty. Because of this the methods of pruning and training of red raspberries differ from those employed with the black and purple types and are described separately.

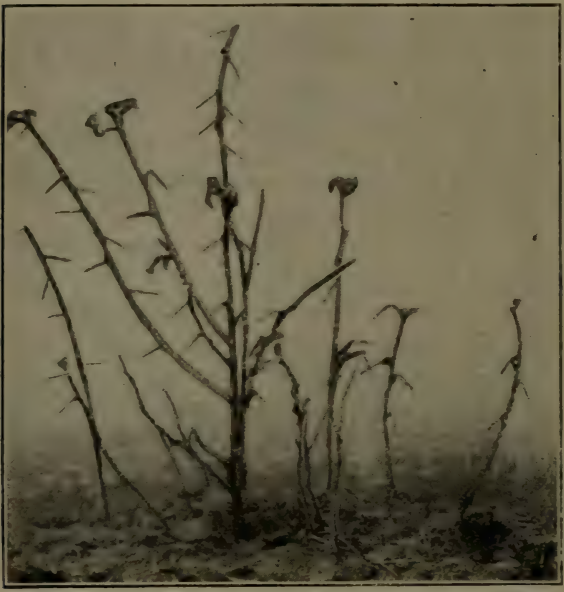
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FIG. 12.—A Ruby red raspberry plant having two strong canes which grew from leader buds and with a large number of suckers springing from the roots.

The system of training and pruning varies not only with the type of raspberry, but also with the vigor and nature of the variety, with climatic conditions, with the cost of materials, and with the preference of the grower. Thus, the Ranere red raspberry makes a dense growth of comparatively slender canes, while others, like the Marlboro and Ruby, make fewer canes, which are much stouter and more erect. The Ranere is not a tall-growing variety, but the Cuthbert canes grow very tall. Varieties of the black and purple types do not show such great differences in growth as the red sorts. Nevertheless, the training and pruning system to be used with these types also will depend to a large extent upon the habit of the variety.

Under the conditions which are found in New England, canes of the Marlboro red raspberry usually grow from 3 to 5 feet high, yet in Washington and Oregon they may grow to a height of 10 to 14 feet. Similar differences occur when other varieties are grown in such sections and make it necessary to use training and pruning systems especially adapted to local conditions.

Reference to the figures illustrating the principal methods will indicate how different is the growth of plants in different sections and how numerous are the systems of training. Many variations and modifications of each of these are used, but only the principal ones will be described.

Three methods of culture of red raspberries are in use—the hill, the linear, and the hedge systems. As the planting plan of each is different, the system to be used must be determined before the plantation is set.

TRAINING RED RASPBERRIES UNDER THE HILL SYSTEM OF CULTURE.

Under the hill system, the plants should be set about 5 feet apart each way. A stake 2 to 4 inches in diameter should be driven into the ground beside each plant when it is 1 year old and the canes tied twice to each stake, once about half way up and again at the top of the stake. Five to seven canes should be left to each plant, the others being cut out. Ordinarily no pruning back of the tips is needed. Figures 8 and 9 show fields of the Perfection raspberry grown under this system. The canes of this variety grow fairly tall and the stakes in this case are about 6 feet above ground. Other varieties have shorter canes and the stakes should correspond to their height. Varieties like the Marlboro, Ruby, and Perfection may be grown under this system easier than those which make a rank growth of suckers, as does the Ranere.

This system is used in New York State very extensively and is to be recommended for sections having similar conditions. To secure the advantage of this system, however, it should be possible to cultivate in both directions with comparative ease, and it should be possible also to secure stakes at a reasonable cost.

TRAINING RED RASPBERRIES UNDER THE HEDGE SYSTEM OF CULTURE.

Where the canes are stout and from 3 to 5 feet tall, growers often allow a solid row or hedge 2 to 3 feet wide to form, as shown in figure 13. This system is very common over all the eastern United States and is adapted to such short-caned varieties as the King, Marlboro, Herbert, and Ruby. A modification of this system is used extensively in New Jersey in growing the Ranere. The canes of the Ranere are comparatively slender, and in early spring growers cut the tops back with hedge shears so that they can support the crop in an erect position. Sometimes the Cuthbert also is grown under this system, as shown in figure 14.

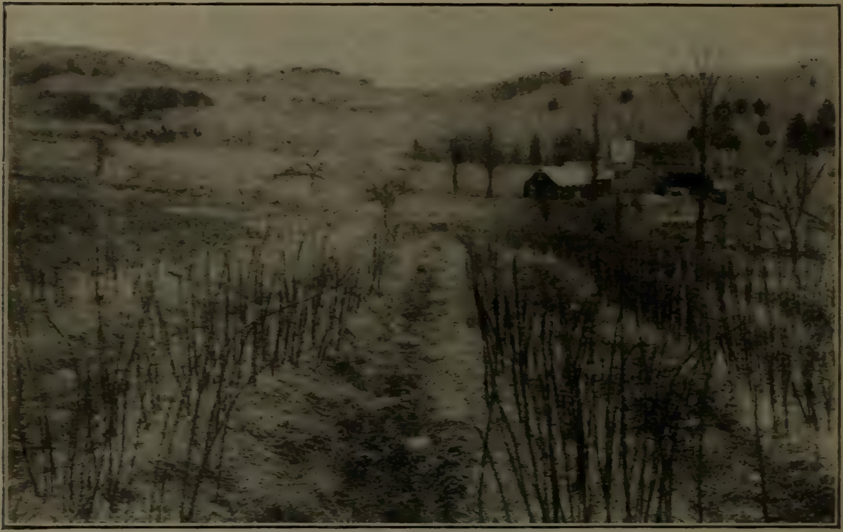
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FIG. 13.—Ruby red raspberries at Putney, Vt., planted in accordance with the hedge system and mulched with straw. The rows are too wide for the best results.

The hedge system is modified further in some sections where the canes grow taller or are not stout enough to hold the fruit in an erect position. Under such conditions a "horizontal trellis" is made when the plantation is 1 year old by stringing two wires along each end of crosspieces which are attached to posts set every 15 to 30 feet in the rows. The wires support the canes, so that they are not broken by pickers or by those doing the cultivating. No pruning back is done. This system is used somewhat in New York, in California, and in other States. A slight modification of it is used in the irrigated sections of eastern Colorado, where the canes are buried in the winter for protection against the cold. In this region posts are set only at the ends of the rows, as illustrated in figure 15. The wires, which hold the canes erect, are held in place by wooden supports, as shown in figure 16. These supports hold the wires about 2 feet high and 1½ feet apart and can be taken down at any time, so that the wires will drop to the ground and thus be out of the way.

This system, called the wide hedge system, has serious disadvantages. When the row is from 2 to 3 feet wide it is difficult to get the berries picked; there always are some weak canes which bend over so that the fruit becomes dirty; there is such competition between the canes for moisture and light that the fruit is smaller than it otherwise would be; and unless the rows are more than 8 feet distant a 2-horse cultivator can not be used. Perhaps the most serious disadvantage of this system is that it is very difficult and expensive to keep such fields free from grass and weeds. If a sod is once formed, it is often cheaper to set a new plantation than to clean out the old one.

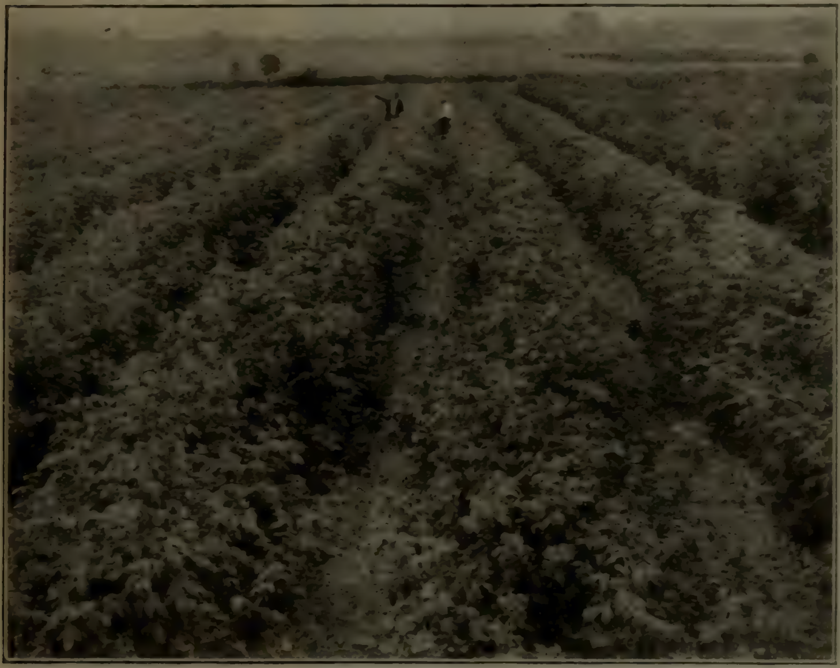

Fig. 14.—A field of Cuthbert red raspberries planted in accordance with the hedge system. The canes are pruned back in the spring, so that they will support the crop of fruit. (Photographed at Webster, N. Y., July, 1915.)

The best form of the hedge system for most sections is that called the narrow hedge system, illustrated in figure 17. Suckers are allowed to grow up only in the rows between the plants originally set, and all others are kept out. The rows then will be about 12 inches wide, and a large part of the tillage can be done with a cultivator. Wire trellises are used with this, as with the wide hedge system, when the canes are very tall or very weak. No pruning back in the spring should be done.

For much of the country, this narrow hedge system is one of the most desirable systems and should be adopted by growers in place of the wide hedge system unless the hill or linear systems can be used.

TRAINING RED RASPBERRIES UNDER THE LINEAR SYSTEM OF CULTURE.

The linear system, which differs from the hedge system in that no suckers are allowed to grow, seems to be becoming more popular and is to be preferred to any other in some sections. It is coming to be used very commonly in training raspberries in all parts of the United States where varieties are grown which have strong erect canes, and it is the only system used to any extent in the State of Washington. The simplest form of this system is that used where the canes are stout and short and will hold an erect position when bearing a full crop of fruit. All sucker plants should be removed and the plants originally set kept for fruit bearing. Most of the cultivating can be done with the horse cultivator, and comparatively little handwork is necessary. Many prune back the tall-caned varieties in the spring and grow them by this system.

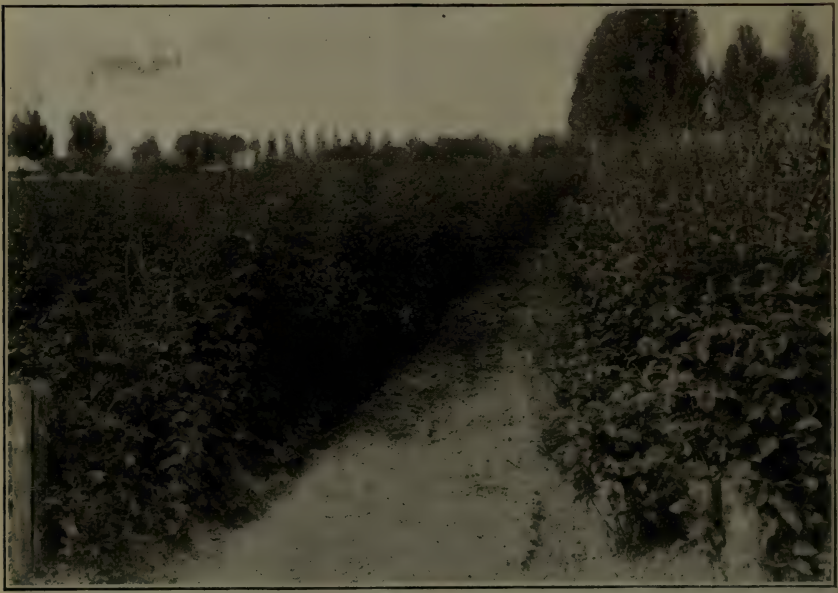

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FIG. 15.—A field of Marlboro red raspberries planted in accordance with the hedge system of culture. The canes are held erect by a 2-wire horizontal trellis. Note the irrigation ditches. (Photographed at Loveland, Colo., July 22, 1916.)

Where tall-caned varieties are grown and where the canes of many of the common varieties are very tall, various modifications of the linear system are used. The canes may be held erect by a horizontal 2-wire trellis, such as is used in the hedge system. Two wires, one on each side of the row, hold the canes erect and are placed between 3 and 4½ feet above the ground. Sometimes when the canes are very tall they are pruned back to a height of 5 or 5½ feet and then held erect by a 2-wire trellis, as shown in figure 18. Sometimes, to make picking more convenient, the canes are tied to the wires on either side and the new canes are allowed to grow up between the wires, as illustrated in figure 9. Thus the fruiting canes are separated from the new ones.

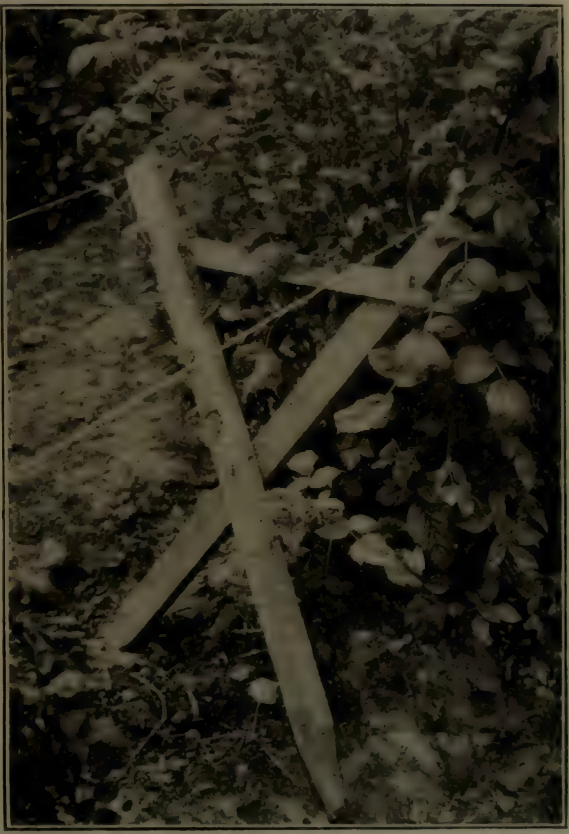

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Fig. 16.—A wooden support used in raspberry fields where two wires hold the bearing and young canes upright. A bent nail keeps the wires from slipping below the desired height.

Some growers use another form of wire trellis, where all the fruiting canes are tied to a single wire, as in figure 20; or, when very tall, to two wires, one above the other, to hold them erect. The tying is cheap and is done easily by children. Figure 21 shows a simple method of tying where each cane is tied separately. A hard knot should be made every few feet, so that if the string breaks the damage may not be extensive. Where some provision is needed to keep the new canes out of the way of pickers and cultivators, an additional wire is strung along just before picking. This system of training to a wire trellis is in common use in most raspberry sections.

Where the canes of the Cuthbert variety grow to the height that they do in the Puyallup Valley in Washington, the growers use some system of training that will bring the fruit within reach of the

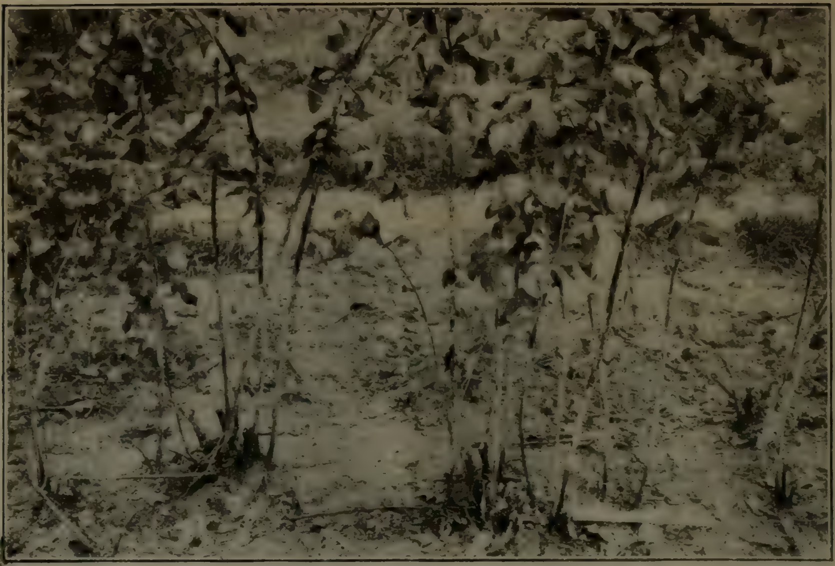

FIG. 17.—Red raspberries planted in accordance with the narrow hedge system of culture. The canes are kept in a row about 12 inches wide and are well spaced in the row. (Photographed at Excelsior, Minn., September 26, 1916.)

pickers, and that will confine the canes and keep them out of the way in cultivating and picking. Sometimes the canes are topped, as shown in figure 18. Sometimes, however, the canes are arched over the upper wire of a 2-wire trellis and tied to the lower wire or to the canes of the next hill, as in figure 22. A cheaper and very satisfactory system is to arch the canes over a single wire, catch them under the canes of the next hill, and weave the ends along the wire and among the canes, as in figure 23. In order to distribute the fruiting space more uniformly, it is better to weave each cane separately than to have all the canes of a hill woven together. As the berries borne on the ends of each cane ripen first, fields trained by these weaving systems produce the earliest fruit. In order to make picking easier, the posts and wires may be placed a foot to one side of the row. If the rows run east and west the trellis should be a foot to the south of the row. The fruiting canes then lean to the south and the young canes will grow up separated from them. Pickers and the carriers of berries will then be shaded by the young canes of the adjoining row. Such youhg canes are held erect by one or two wires on the north side of each row, which are strung along the ends of crosspieces at a suitable distance from the fruiting canes.

Many modifications of these systems are in use and are adapted to particular conditions. The linear system, where only the original plants are kept for fruiting, or the narrow hedge system, where the original plants and a very few suckers well distributed between them are retained, are generally the best. The life of the plantation under these systems is much longer, it is easier to conserve moisture in times of drought, and the picking is easier than in plantations trained to the wide hedge system.

The hill system is adapted only to localities where varieties which produce comparatively few canes are raised, where stakes are cheap, and where cultivators can be run easily in both directions.

No pruning back of red raspberries should be done under any system if it can be avoided, as the removal of the ends usually lessens the crop and makes it somewhat later.

TRAINING AND PRUNING BLACK AND PURPLE RASPBERRIES.

Nearly always the black raspberries and the purple raspberries now under cultivation are planted on the linear system, and as they do not send up suckers from their roots, their training is much simpler than that of the red raspberry. The young canes should be topped, in order to make them able to stand erect when bearing a heavy crop of fruit. Black raspberries should be topped at a height

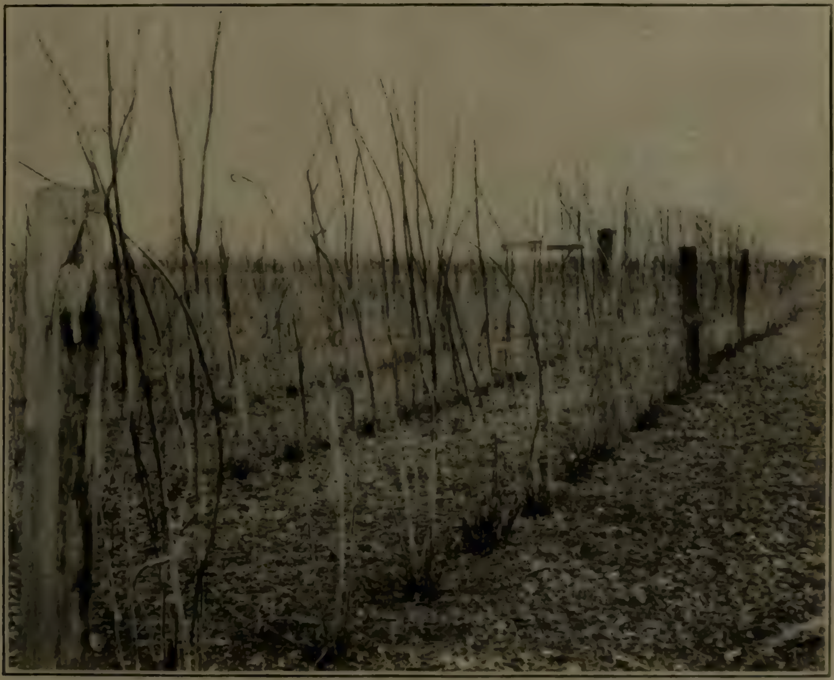

FIG. 18.—A field of Cuthbert raspberries under the linear system of culture. Two wires, one on either side, hold the canes erect. The wires are about 4 feet above ground and the canes topped about 6 feet from the ground. (Photographed at Puyallup, Wash., February, 1915.)

of 12 to 30 inches, depending on their vigor, 18 inches being the most common height. Purple raspberries should be topped at a height of 30 to 36 inches, as their growth is more vigorous. The topping may consist in cutting off the ends of the canes after all have reached the desired height, and usually it is done just before picking.

Topping also may be done by pinching off with the fingers the ends of the young canes as soon as they reach the proper height. In this case it will be necessary to go over the plantation several times, as the new canes do not all reach this height at the same time. Generally it will be much better to pinch off the ends rather than to cut them back.

Side branches called laterals will grow from the buds along the cane which has been pinched or pruned back. These laterals will grow to a length of several feet by late summer. In early spring, before growth starts, they should be shortened according to the vigor of the plant and the habit of the variety. The fruit is borne on the growth of the current season, which starts from the well-developed buds on the laterals, and the amount of fruit can be controlled by

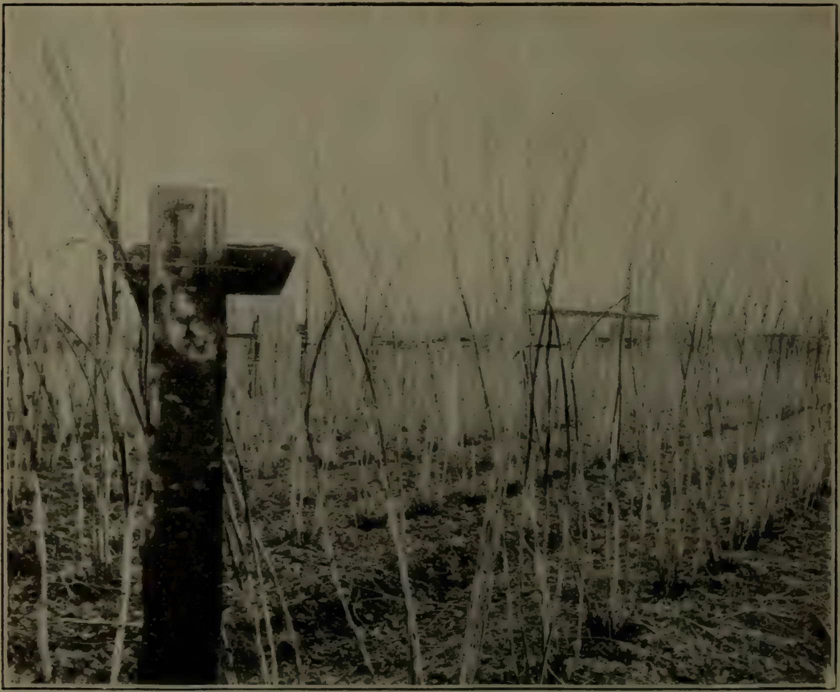

Fig. 19.—A field of Cuthbert raspberries planted on the linear system of culture. The fruiting canes are tied to wires on either side or held in place by extra outside wires, and the young canes grow up between the fruiting canes. Topping may be practiced if desired. (Photographed at Puyallup, Wash., February 18, 1915.)

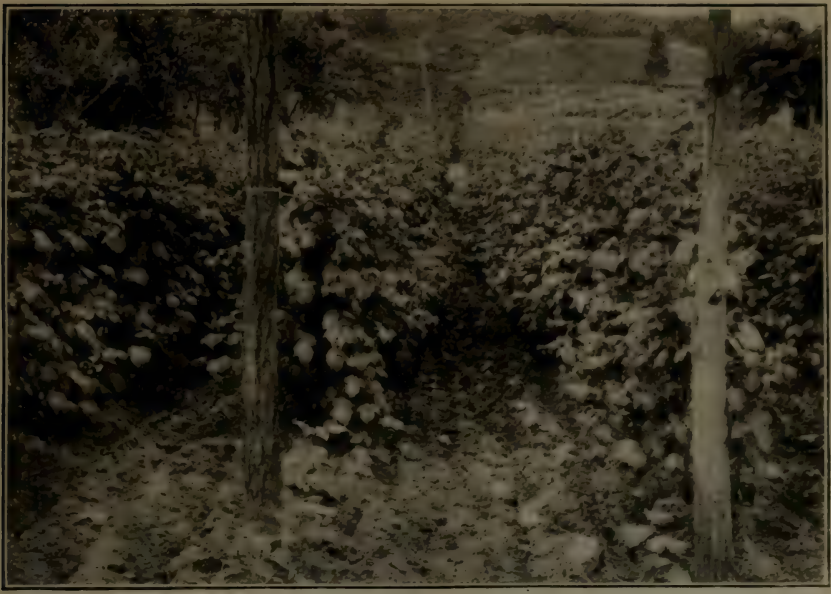

FIG. 20.—A field of 7-year-old Empire red raspberries trained to a single-wire trellis under the linear system. The bearing canes are tied to the wire to hold them erect. (Photographed at Marlboro, N. Y., June 23, 1915.)

the number of buds left on them in the pruning. Varieties differ in the location of the buds and should be pruned accordingly. Sometimes the buds start very near the base of the lateral next to the main stem and sometimes at a distance from the base. The laterals in the former case should be pruned shorter than where the buds are borne at a distance from the base. Usually the laterals on black raspberries should be 8 to 12 inches in length, but those on the purple-caned varieties should be 12 to 18 inches long. If the laterals are left too long and too much fruit is allowed to develop on them, the new canes will be weak and sometimes none will grow. Thus the extra fruit is secured at the expense of the crop for the following year. Figure 24 shows a field of purple raspberries trained to the system described above, and figures 25 and 26 illustrate the method of pruning both black and purple types.

Sometimes the canes of black raspberries are topped at a height of 3½ to 4 feet and a 1-wire trellis or a horizontal trellis with a wire on each side of the row is used to hold the canes erect. In other cases they are not topped but are trained to trellises, as described for training red raspberries. Rarely, however, are the purple varieties trained under any system other than that which includes topping at a height of 2½ to 3 feet and pruning back the laterals in the spring to 12 to 18 inches. The expense of such a system is less than where a trellis is used, and under ordinary conditions the maximum amount of fruit of both black and purple raspberries will be secured at a minimum cost.

REMOVING OLD CANES AND THINNING NEW CANES.

In nearly all sections, under all systems of training, the fruiting canes should be removed as soon as the crop has been harvested. If this is done the young canes have more room in which to develop and will have more sunlight. Also it is supposed that by the removal and burning of the old canes on which may be insects and diseases, the plantation will be kept in a healthier condition.

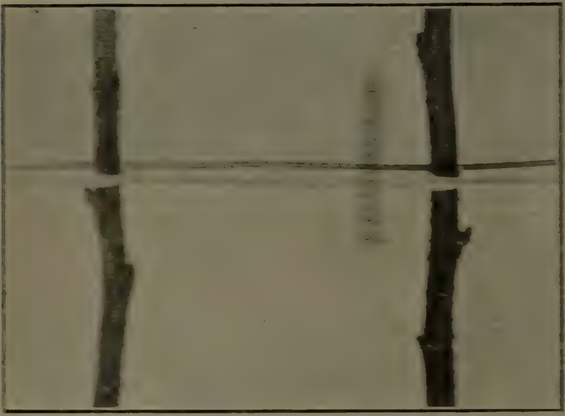

FIG. 21.—Raspberry canes tied to a wire trellis. Canes can be tied very rapidly when this system is used, and the cost per acre is small.

At the same time that the old canes are cut out the young canes and suckers should be thinned. Where red raspberries are kept in hills, all suckers and all the weaker new shoots should be removed. Ordinarily 5 to 7 strong, vigorous canes should be left, but as high as 8 or 9 canes may be safely left in vigorous hills where the plants are set 5 feet apart each way. In the irrigated sections of Colorado, however, it is considered best to leave 8 to 12 canes per hill of the Marlboro variety. The Ranere in New Jersy makes a large number of small canes, and as many as 10 or 12 may be left to each hill. Sometimes, in order to secure a large crop on the new canes of the Ranere in late summer, all canes are cut off at the ground in early spring and the strength required to mature an early crop forced into cane production. Four or five canes per hill of the black and purple raspberries should be left under all systems.

When the hedge system is used the canes should be thinned so that they are not closer together than 8 inches. When several canes appear from the same crown, the more vigorous ones should be left. Figure 17 shows proper thinning under this system. Figures 18, 19, 22, and 23 show fields under the linear system in which the canes have been thinned properly, and figures 8 and 27 show red raspberries under the hill system where the canes have been thinned correctly.

Different types of cane cutters used for removing the old canes and surplus young ones are shown in figure 28. The cutter with a V-shaped blade is perhaps the most satisfactory of those shown in the figure, as the cut can be made with less danger of tearing up the plant or injuring other canes. When the blade is kept sharp and a quick pull is given, such cutters are very satisfactory. Pruning shears of various types are often used on small plantations. In New Jersey, where the Ranere is grown extensively, hedge shears are used to cut off the ends of the young canes which have fruited, and to prune the canes back to the proper height.

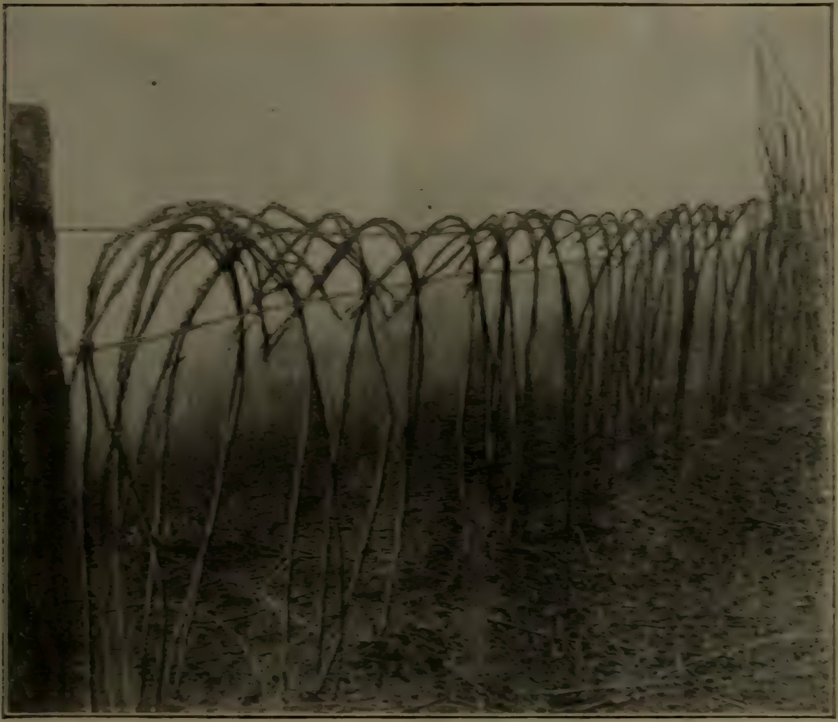

FIG. 22.—Red raspberries planted on the linear system and trained to a wire trellis. The canes are arched over the upper wire, tied to the lower wire, and the projecting ends cut off. (Photographed at Sumner, Wash., February 17, 1915.)

PRUNING FOR LATE FRUIT.

In order to extend the season of red raspberries for the home table, the canes should be cut back to within about a foot of the ground in the autumn or in early spring. The strength of the plant then will go into the lower buds and a long shoot will be made before the flowers appear. The fruiting season may be extended from two to four weeks by this practice, but the crop will be reduced considerably.

WINTER PROTECTION.

In many parts of Colorado and in some of the western North-Central States raspberry canes must be protected from the cold drying winds of winter. Usually soil is used for this purpose, and is more satisfactory than straw or similar material. The canes are all bent over in the same direction and held down by a clod of earth or a piece of old cane broken half in two. A furrow of earth is then thrown over them with a plow and later smoothed by hand labor so that the canes are entirely covered. The labor required to do this is considerable, and records show that by this method it costs from $30 to $40 per acre to cover the canes and to uncover them the following spring.

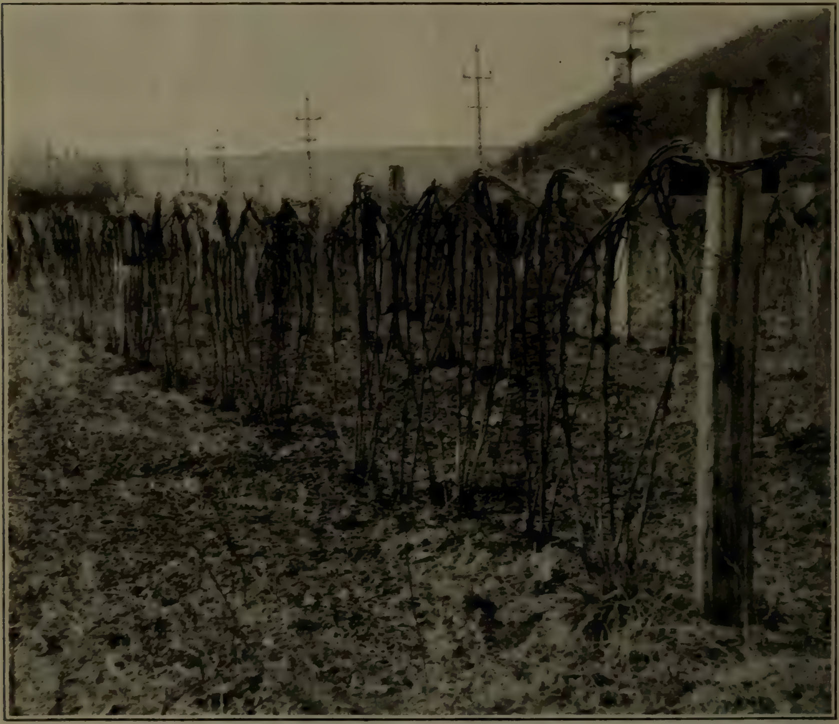

FIG. 23.—Red raspberries planted on the linear system and trained to a wire trellis. The canes are bent over the wire and caught between the canes of the next hill. It is usually better to weave each cane separately than all the canes of a hill together, as is shown here. (Photographed at Sumner, Wash., February 17, 1915.)

Another method, used in Idaho, in covering extensive areas of black raspberries. is to draw an implement like the one shown in figure 29 over the row of canes. The front is high and wide and the back low and narrow. When this is drawn over the bushes, the canes are left lying along the row close to the ground. Plows, one on each side of the row, are placed so that the plants are covered by the furrows thrown to the center from either side. Furrows 10 to 14 inches wide and not over 4 inches deep should be turned on the bushes. The size of the furrows will depend on the stand of canes. This implement with two plows attached can be drawn by two horses and managed by three men. About 10 acres per day can be covered at a cost of approximately $1.25 per acre. If the implement is well made it will not bruise the canes badly, and it can be constructed at a cost of but a few dollars by any berry grower.

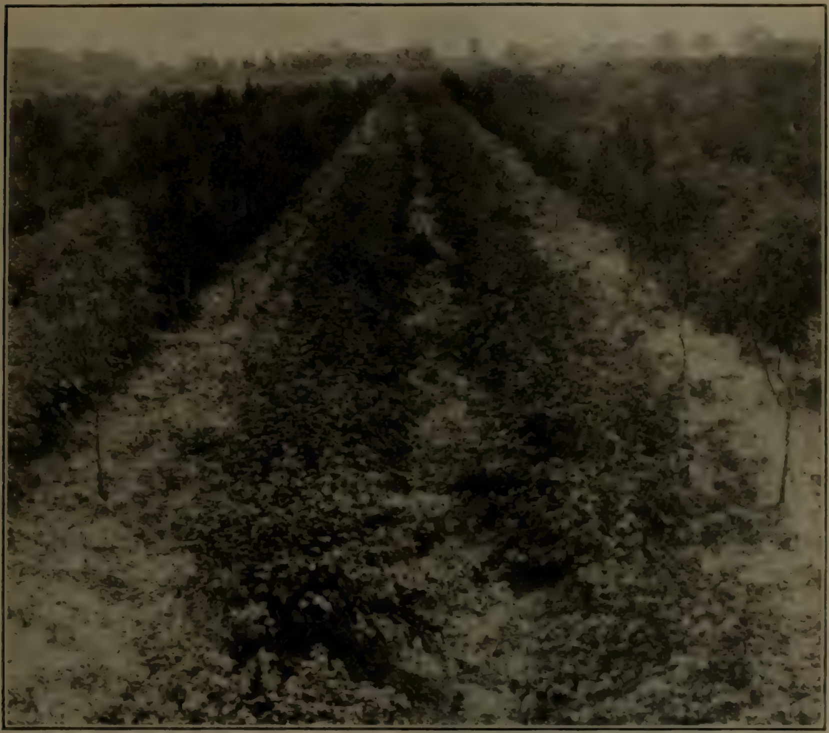
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Fig. 24.—Columbian purple raspberries planted in accordance with the linear system. Each plant is made to support its crop of fruit by careful pruning. The canes were topped 2 feet high and the laterals pruned back to 18 or 20 inches. (Photographed at Webster, N. Y., July 15, 1915.)

The canes should be uncovered in spring before growth starts and yet not until after danger from severe weather has passed. Sometimes a gradual removal of the soil will be found advantageous. The canes will then become accustomed to the air and light by degrees and there will be less danger of injury to the buds.

DURATION OF A PLANTATION.

The factors which determine the number of years a plantation will be profitable are not entirely understood, but to a large extent they depend on the care given it. In the Puyallup Valley of Washington, some red raspberry plantations have been bearing good crops for 15 years and show no signs of becoming less fruitful. In the eastern United States raspberry fields nearly as old are still in good condition, and small patches are much older. The canes in such fields have been thinned regularly and the moisture supply kept up by constant cultivation and by furnishing a plentiful supply of humus. In the care ordinarily given the average plantation the moisture supply is allowed to become deficient at times, and the new canes do not have an opportunity to develop as they should. Sometimes black and purple varieties are allowed to bear so heavily that they can not send up new canes, and such plants die. Often diseases and insects affect a plantation so that it becomes unprofitable. By systematic pruning, by maintaining the humus supply, and by constant culti-

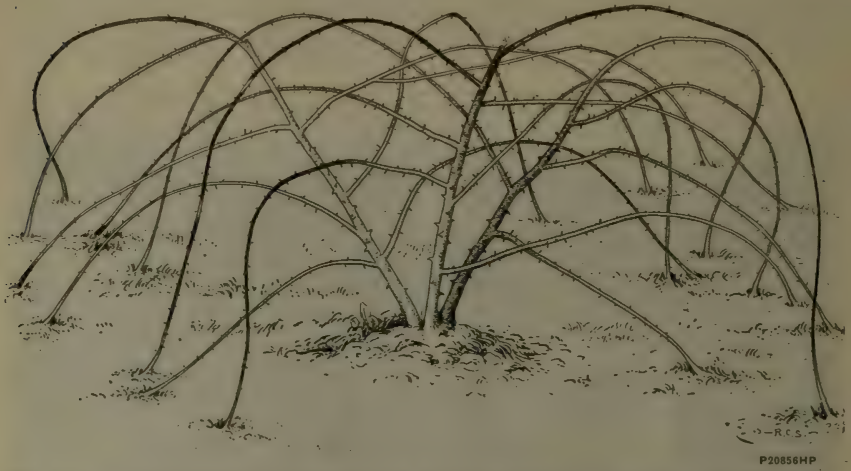

FIG. 25.—A black raspberry plant with the laterals rooting at the tips. (See figure 26.)

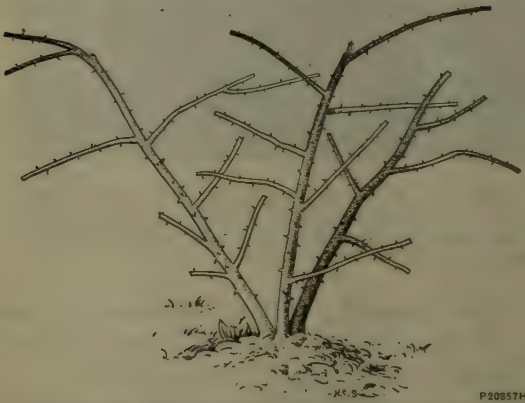

FIG. 26.—The black raspberry plant shown in figure 25, after it had been pruned.

vation the life of the plantation should be extended indefinitely. Perhaps the average length of life of a plantation in the Eastern States is 8 to 10 years for red raspberries, and 6 to 8 years for black and purple raspberries.

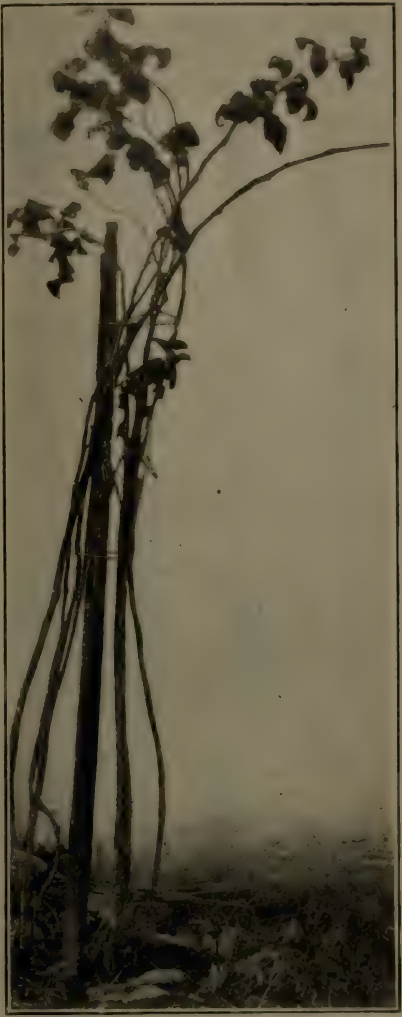

Fig. 27.—A plant of Perfection red raspberry grown in accordance with the hill system, the canes being trained to stakes. Seven canes have been left for fruiting. (Photographed at Milton, N. Y.)

HARVESTING.

Raspberries should be handled as carefully as possible in harvesting, in order to avoid injuring them. The subsequent behavior of the fruit on the market depends in a large measure upon the care used in picking and handling.[1] Berries injured or bruised in handling, or soft from being overripe or from rainy weather, are attacked quickly by certain mold fungi which cause their decay. To avoid as much injury as possible in picking, three fingers always should be used; very few berries should be held in the hand at one time; the berries always should be placed, not dropped, into the basket or cup; all decaying, overripe, and injured berries should be discarded; and no later handling of the berries in the basket for any purpose should be allowed.

Carriers used in picking are shown in figures 30 and 31. The berries should be picked into baskets carried in the waist carriers. As soon as the baskets are filled they should be transferred to the hand carrier, which always should stand in the shade. Waist carriers suspended from the shoulders, like that shown in figure 31, are not as likely to spill the berries as are those suspended from the waist.

In many sections the waist carrier holds two baskets, one for very ripe fruit and one for firm berries suitable for shipping. The very ripe fruit is used for canning and the firmer fruit for shipping to distant markets. When pickers are trained to use both baskets they lose very little time in the grading. Usually six to eight pickers per acre are needed in harvesting.

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[1] See Ramsey, H. J., Factors governing the successful shipment of red raspberries from the Puyallup Valley. U. S. Dept. Agr. Bul. 274, 37 p., 26 fig. 1915.

In western New York, where black raspberries are grown for drying, the berries in most cases are not picked by hand. Instead, a harvester or "bat" is used, with which a man can harvest from 5 to 8 bushels of berries a day. The "harvester," shown in figure 32, is placed somewhat under the bush, and the bush is drawn over it by a short wire hook held in the left hand. The ripe berries are then knocked off with a light wooden paddle, like that shown in figure 33, and fall into the harvester. More than half of the crop is secured the first time the field is gone over. Usually the remainder of the crop can be harvested by going over the field a second time. In some seasons it will be necessary to perform this operation a third time in order to get all of the fruit.

In Idaho, berries of the Gregg variety are allowed to dry on the bushes. The bushes then are cut and bundled. As soon as they are dry, the berries are separated by thrashing. The berries, thus separated, hold the receptacle and have short stems, which are removed by running through a roller machine. This system is adapted only to sections with nearly rainless summers.

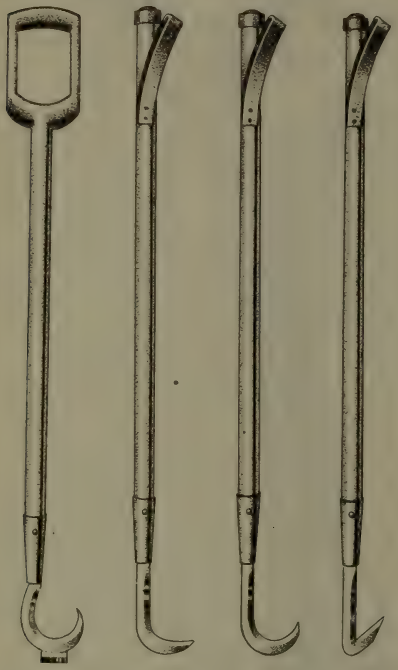

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FIG. 28.—Homemade raspberry-cane cutters used to cut out the old canes and superfluous new ones. The total length of the cutters is about 34 inches. Straps on the handles of those at the right enable the worker to maintain a firm grip. The V-shaped blade on the cutter at the right is considered the most desirable.

YIELDS.

Yields from raspberry plantations vary greatly according to the varieties raised, the care given them, and the conditions under which they are grown. In the eastern United States it is agreed generally that in sections to which they are adapted the purple sorts are the most productive, the blackcaps next, and the red varieties the least productive. Records of red-raspberry growers in New York State indicate that the average yield is between 1,300 and 1,400 quarts per acre, while the best fields go as high as 4,000 quarts. Black raspberries in the same State average between 1,400 and 1,700 quarts per acre, and the purple varieties average between 1,700 and 2,300 quarts.

Yields in different sections as well as from different varieties vary greatly. In the Loveland section of Colorado the Marlboro variety will yield over 4,000 quarts per acre when protected during the winter and when other conditions are favorable. In the Puyallup Valley of Washington, fields of Cuthberts properly cared for will yield 6,000 quarts per acre and the Antwerp 8,000 quarts per acre. Eastern growers who have given their plantations as intensive care as is given in Washington have been getting yields nearly as large as those secured in that State.

DISEASES AND INSECTS.

There are several serious diseases and insect enemies of the raspberry. Among the serious diseases of the plants are anthracnose, spur-blight, yellows, and cane-blight. Cane borers and "red spider" are among the more serious insect pests. Information in regard to the control of diseases and insects may be secured by writing to the nearest State agricultural experiment station or to the United States Department of Agriculture at Washington, D. C., and furnishing specimens of the insects and the affected parts.

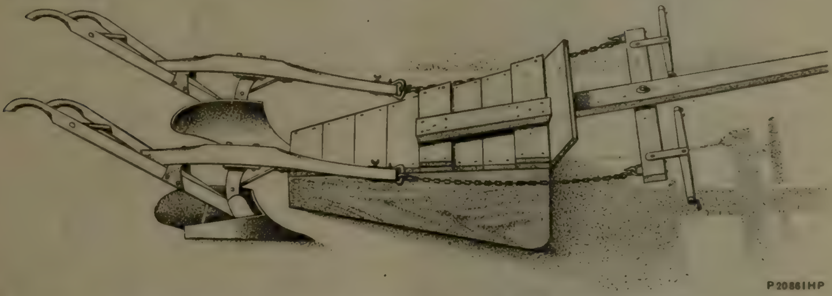

FIG. 29.—Implement used in covering raspberry canes for winter protection. The evener must be made long enough to allow the horses to pass one on each side of the row.

PROPAGATION.

Plants of the different varieties of raspberries may be secured from any reliable nursery and usually in starting a new plantation this is done. Many growers having an established plantation propagate their own stock.

To propagate new plants, the tips of the new canes of black raspberries and of the purple varieties now under cultivation should be buried in moist soil in late summer. By the following spring, the tips will have rooted and formed good plants. The cane then should be severed, leaving 4 to 8 inches of cane with the new plant which is to be set in the field, as shown in figure 6.

If the tips of the canes of black and purple varieties are pinched off when they are about 12 inches high, the canes will branch freely and a large number of tips for burying will be secured. With many growers the first crop from both black and purple raspberry plantations is a crop of plants. In fact, a large part of the plants distributed by nurserymen are produced in this way by raspberry growers, who in turn sell them to nurserymen.

Red raspberries send up new canes from the base of the old canes, as do black and purple varieties. In addition, they send up suckers from underground roots at various distances from the crown of the parent plant. In starting a new plantation the strongest of these suckers are used. If a quantity of plants for setting is needed each year for several years, it may prove desirable to take up all plants in a given part of the field, both the old ones and the suckers. By the following year, a solid stand of plants suitable for setting will have sprung up from the pieces of roots left in the ground. When these are dug and the ground is rich, another stand will grow for the following year. If this practice is followed, the fruiting plantation need not be disturbed by digging up sucker plants. Sometimes growers of the Marlboro and Ruby varieties wait until suckers appear in the spring and set these out. Such plants will be small, but should be very free from insects and diseases.

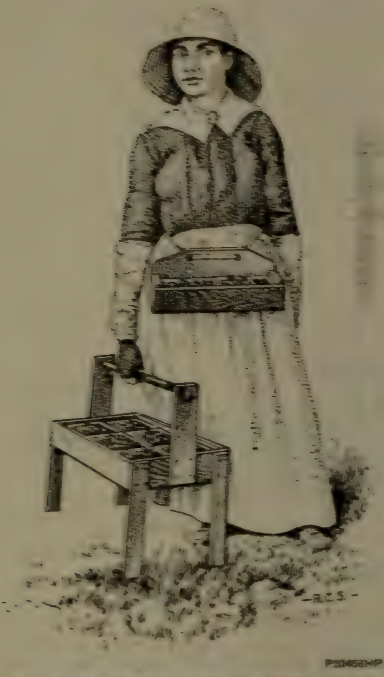

FIG. 30.—Waist and hand carriers. The waist carriers hold two cups or baskets and the hand carriers six.

Raspberries may be propagated also by cuttings of the roots or canes if necessary. In ordinary practice, however, cuttings of either roots or canes are rarely used.

VARIETIES.

The varieties of raspberries under cultivation have come from different parts of North America and Europe and are adapted to different conditions of environment and to different uses. Thus the Sunbeam and Ohta originated in South Dakota and generally withstand the trying conditions of the cold winters there. The Superlative, which originated in Europe, where the winters are milder than in most raspberry-growing sections of this country, is grown only in the Pacific Coast States. The King is a desirable variety throughout the region between the Mississippi River and the Appalachian Mountains, where raspberries succeed. In New York and New England, however, it has proved, for the most part, inferior to many other varieties.

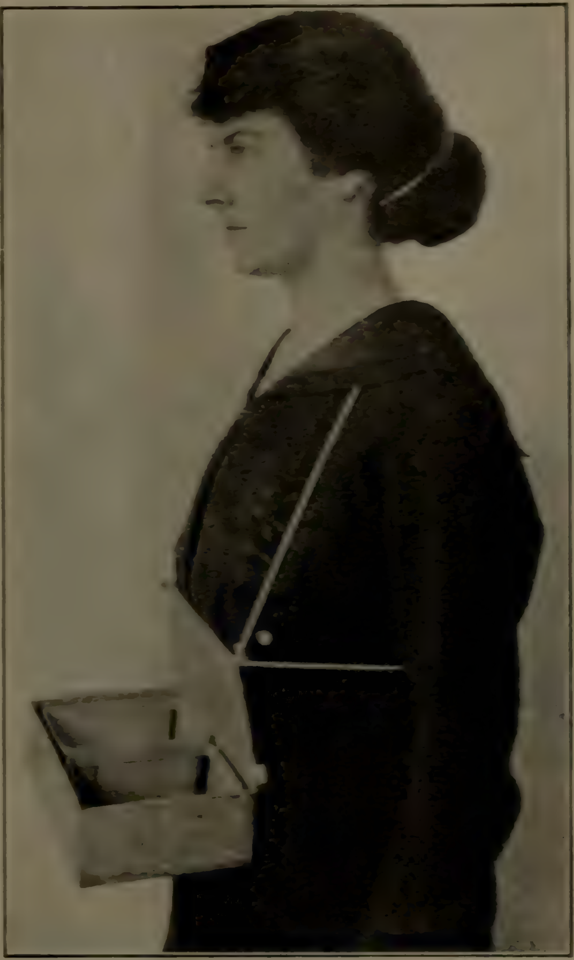

FIG. 31.—A picking carrier made to hold two oblong pint baskets. This carrier is suspended from the shoulders and is not likely to spill the berries when the picker is bending over.

In selecting the varieties of raspberries to cultivate in any locality it is usually important to consider (1) the hardiness of the canes, (2) the productiveness of the variety, and (3) its fitness for the particular purpose for which the crop is to be used. In the characterizations here given special attention has been paid to these points. Thus, if in western New York State varieties are desired through a long season, the following may be selected: For red varieties, the Perfection, June, or Empire for early, the Cuthbert for late, and the Ranere (*St. Regis*) for its fall crop: for black varieties, the Farmer and Cumberland: and for purple varieties, the Columbian and Royal. In the Middle West, the list should include: For red varieties, the King and Loudon, or perhaps the Ranere and Cuthbert in sheltered places and the Sunbeam in very exposed places; for black varieties, the Kansas, Farmer, and Cumberland: and for a purple raspberry, the Cardinal. In Oregon and Washington, a satisfactory list may include: For red varieties, the King or Marlboro for early, the Cuthbert and Antwerp for late; and the Farmer and Cumberland for blackcaps. In California, generally, the Surprise red raspberry is considered the best variety. The season of ripening for these raspberries is given in the characterizations.

These lists for the different sections are suggestive only, as in certain localities the varieties named may not prove equal to others. In the United States as a whole, the Cuthbert is the leading red variety. Growers seem to prefer to plant a single variety rather than several varieties and commonly select the Cuthbert. In New Jersey, however, the Ranere is the variety usually grown; in Michigan it is the King, and in Colorado, the Marlboro. In the Hudson River valley the Perfection is selected in preference to others.

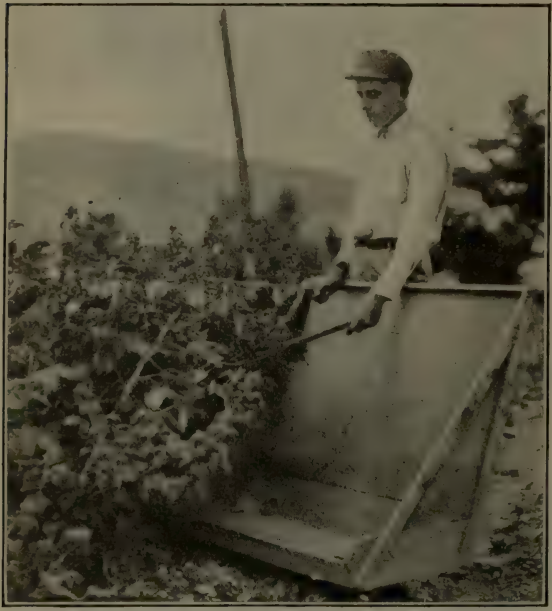

FIG. 32.—Harvesting black raspberries for the evaporator with a harvester or "bat." The canes are drawn over the harvester with a wire hook held in the left hand, and the berries are knocked off with a paddle in the right hand.

If varieties suited to special uses are desired, the following suggestions will prove helpful.

For jams and preserves, the Cuthbert, Cardinal, Columbian, and Royal are especially desirable.

For canning, the Cuthbert or Loudon, among the reds; the Cardinal, Columbian, or Royal among those of purple color; and the Farmer and Cumberland among blackcaps. Other varieties may be equally desirable for some localities, but the commercial industries are based largely on those named above.

The following are among the most desirable raspberries in cultivation at the present time.

RED AND YELLOW VARIETIES.

ANTWERP.—European origin. Berries large, slightly conical, dark red, fairly firm, rather acid; season early, but later than Marlboro. Bush tender; subject to crown-gall; grown only on the Pacific coast, where it is used chiefly as a companion to the Cuthbert; in Washington, at least, it is more productive than the Cuthbert. Not hardy in most other parts of the United States.

CUTHBERT.—New York origin. Berries large, conical, deep, rich crimson, firm; season late. Bush moderately hardy, being tender in Minnesota and other North-Central States, sometimes also in exposed locations in New York and in the region near the Atlantic coast in New Jersey and New England; canes very tall. The principal variety in many sections, and one of the best for canning. Adapted to sandy loam, but will do well on a wide range of soil types.

EATON (*Idaho*, *Iowa*[1]).—Indiana origin. Berry very large, crumbles badly, and does not separate easily from the receptacle in some sections, very acid; midseason, ripening through a long period. Bush hardy with short, stout, erect canes. In New England, this has proved to be the most productive of all red raspberries, but because of its poor quality and its tendency to crumble and rot before ripening it is not desirable except for jam and preserves. In the Central States it does not usually make a sufficient number of canes to produce well.

EMPIRE.—New York origin. Berries large, bright red, firm; season early and very long. Bush hardy in the Hudson River valley and western New York, very vigorous; canes stout, tall, and very productive. A promising new variety in New York. Recommended for testing in all sections for both home use and market.

GOLDEN QUEEN.—New Jersey origin. Berries similar to the Cuthbert except in color, which is yellow. Bush very similar to the Cuthbert in all respects. Desirable for home use and for amateurs, and adapted to the same conditions as the Cuthbert.

HERBERT.—Canadian origin. Berries large, somewhat conical, bright red, slightly softer than the Cuthbert; midseason, ripening a little earlier than the Cuthbert. Bush usually hardy except in the Central States; prickly, vigorous, with spreading growth. Grown in northern regions where the Cuthbert is not hardy, especially in New England and New York, where it is more productive than the Cuthbert.

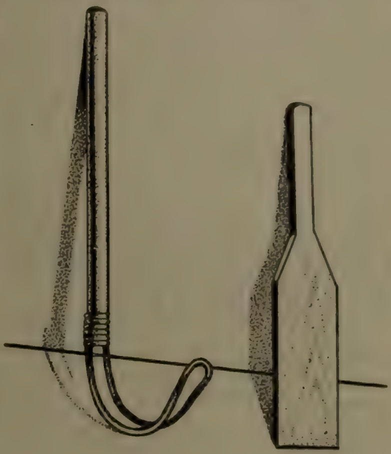

FIG. 33.—Hook and paddle used in harvesting black raspberries in the Dundee section of New York State.

JUNE.—New York origin. Berries large, bright red, firm; season very early and long. Bush entirely hardy in the Eastern States, vigorous. Promising new variety for heavy soils in New York and New England, not widely tested elsewhere; sometimes lacking in dessert quality.

KING.—Berries fairly large in sections to which it is adapted, bright red, firm, dropping from bushes when overripe; season early and long. Bush generally hardy, vigorous. One of the best early varieties; has replaced Marlboro in many sections of the Central West and in West Virginia. Not generally desirable in New York and New England. Very productive on clay loams.

LOUDON.—Wisconsin origin. Berry large, bright red, rather soft, and does not separate easily from the receptacle; midseason. Bush very hardy, especially in the Middle West, canes rather slender there; is quite susceptible to crown-gall. One of the best canning varieties, as it holds its color well when canned. May be grown in the Central West in place of Cuthbert where that variety is not hardy. Usually not as desirable as other varieties here mentioned.

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[1] Another variety is also grown under the name Iowa.

MARLBORO.—New York origin. Berries medium to large, bright red, firm; season early and long. Bush hardy, canes short and stout in the East, but must be supported in Colorado and westward. Frequently grown as a companion to the Cuthbert. Principal variety in Colorado. Adapted to sandy loams somewhat heavier than those on which the Cuthbert does best.

MILLER.—Delaware origin. Very susceptible to crown-gall; is being replaced by better varieties.

OHTA.—South Dakota origin. Berries large, light red, firm, acid; season early. Bush very hardy, prickly, vigorous. Recently introduced. Considered promising in the northern Great Plains area and in other sections having severe winters, but should be tested further.

PERFECTION.—New York origin. Berries large, bright red, very firm, not very good quality; season early and long. Bush hardier than the Cuthbert. The principal variety in the Hudson River valley and grown somewhat in New England, but not widely tested elsewhere.

RANERE (*St. Regis*).—New Jersey origin. Berries small to large, bright red, soft; season very early and long; after the old canes have borne the young canes begin bearing and in New Jersey bear freely until frost. Bush hardy, sends up suckers so freely that very thorough cultivation is necessary to keep them down; very susceptible to crown-gall. Long grown in New Jersey, where usually about five-sixths of the crop is borne in spring and the rest in autumn; should be tested carefully before it is planted heavily in regions where it has not yet been tried, as it will not bear much in the autumn in some regions, and not at all in the autumn in some seasons of drought.

RUBY.—New York origin. Very similar to the Marlboro in fruit, cane, and season of ripening, but reported more productive and fruit firmer. Grown somewhat in the Hudson River valley and in New England; considered desirable as a companion to the Cuthbert in New England; not much grown in other regions.

SUNBEAM.—South Dakota origin. Berries large, bright to dark red, fairly firm, acid; season very early. Bush very hardy, prickly, and vigorous, fairly productive. Recently introduced. Considered promising in the northern Great Plains area where other varieties are not hardy; should be tested further. Withstands drought well.

SUPERLATIVE.—European origin. Berry large to very large, conical, soft; a dark unattractive color when ripe and does not separate easily from the receptacle; quality good in California, rather poor in Washington; season medium early. Bush very tender, very vigorous. This is an English variety, the canes of which are not hardy in the eastern United States; it is considered desirable only in California near San Francisco.

SURPRISE (*California Surprise*).—California (?) origin. Berries medium size, conical, firm, good quality; season early, will bear a good second crop in California the first and second years after setting, but a smaller second crop thereafter; will bear some fruit in southern California almost every month in the year. Bush hardy in California, but hardiness unknown elsewhere; canes slender. The most desirable variety at the present time for central and southern California.

WELCH.—New Jersey origin. Berries good size, fairly firm to soft, deep red; season late and long. Bush hardy. Has superseded the Cuthbert in parts of New Jersey, and is reported hardier than the Cuthbert in that State. Grown very little elsewhere.

PURPLE VARIETIES.

CARDINAL.—Kansas origin. Berries very large, rather soft, but firmer than fruit of the Columbian. Bush very hardy; hardier than Columbian, Haymaker, or Shaffer in the Central West; very productive. Can be grown farther south than most raspberries.

COLUMBIAN.—New York origin. Berries very large, rather soft; season late, about with Cuthbert. Bush usually hardy in the East, but not always hardy in the Middle West; very vigorous; very productive. One of the best canning raspberries and grown more extensively than any other purple variety.

HAYMAKER.—Ohio origin. Berries very large, soft, more acid than Columbian; season very late. Bush usually hardy. Is being superseded by other purple varieties.

ROYAL (*Royal Purple*).—Indiana origin. Berries large, firm; season very late and long, ripening most of its crop two weeks later than Columbian and with the early blackberries. Bush hardy where tested in New York and New England; very productive; canes reddish and nearly smooth. One of the best canning and preserving raspberries. Promising for general culture, but should be tested before it is planted extensively.

SHAFFER.—New York origin. Berries very large, softer than Columbian, rather acid; season late. Bush tender. Is being replaced by other varieties.

BLACK VARIETIES.

CUMBERLAND.—Pennsylvania origin. Berries very large, firm; midseason. Bush usually hardy. Is more widely planted than any other black raspberry because of its productiveness and quality; frequently planted with the Farmer.

FARMER (*Plum Farmer*).—Ohio origin. Berries very large, firm; season early and short; ripening so quickly that the entire crop can be harvested in two or three pickings. Bush hardier than most blackcaps; withstands drought well. Very promising, especially for planting with the Cumberland and for use in sections where black raspberries are grown for evaporating.

GREGG.—Indiana origin. Berries large, firm; midseason. Bush usually hardy and productive. Extensively grown, but being superseded by others in some sections.

HOOSIER.—Indiana origin. Berries ge erally reported small, although large and firm at Pekin, where it originated, and in Missouri; quality excellent; ripens with Cumberland. Bush at Pekin, Ind., hardy and productive; said to be quite resistant to anthracnose.

KANSAS.—Kansas origin. Berries large, firm; season early. Bush somewhat tender. Grown in Michigan with the Cumberland; in some sections is being replaced by Farmer.

OHIO.—Ohio (?) origin. Berries medium size, seedy; midseason. This variety has been used extensively for evaporating, as it produces a larger percentage of the dried product than other sorts except the Farmer, which has replaced it to some extent.

OLDER.—Iowa origin. Berries large, rather soft. Bush vigorous, of a somewhat trailing nature, very hardy for a black variety. Desirable for Iowa and Minnesota conditions.

PEARL (*Black Pearl*).—Missouri origin. Berries large, firm; season early and short. Bush hardy. Grown extensively in Kansas, Missouri, and Michigan but not widely tested elsewhere. Especially desirable as a companion to the Cumberland or Gregg in the above-named States. Very promising at the Maryland Agricultural Experiment Station.

AUTUMN-FRUITING VARIETIES.

Certain varieties of red raspberries will fruit on the young canes in late summer. The best known variety having this characteristic is the Ranere (*St. Regis*), which is grown extensively in New Jersey. Other varieties in the trade are the Erskine (which has larger and better fruit than the Ranere) and the Hailsham (recently introduced into California from England). During seasons with rainy summers or under irrigation these varieties will produce considerable fruit in the late summer and autumn months, but when the moisture is deficient they can not develop good fruit. Growers in New Jersey frequently market large quantities of fruit in August and September, and under conditions similar to those in New Jersey autumn-fruiting varieties are likely to prove desirable.

HYBRIDS AND RELATED FORMS.

At present there are in the trade in this country no hybrids between the common forms of raspberry and other species of Rubus known to be valuable for their fruit, nor are there hybrids between the raspberry and other fruits. A recent hybrid between the Cuthbert and a Chinese raspberry species[1] shows valuable characteristics, but this is not yet available to the public.

Several forms related to the raspberry are being propagated by the trade. Of these the form[2] sometimes called the Golden Evergreen raspberry or Himalayan Golden raspberry, comes from India and southern China and will thrive only in the subtropical climates of southern California and southern Florida. The bush is perennial, and will grow to a height of 15 to 20 feet, with a spread of 30 feet in a few years. Usually it does not begin to bear until it is from 3 to 5 years old and then may sometimes bear annually more than 100 quarts per plant of golden-colored fruit which is about the size of a small black raspberry. The fruit is of only fair quality, but is of some value for home use in regions where other berries will not grow. Other forms widely advertised at times are the Wineberry,[3] which is a native of Japan and China, bearing cherry-red insipid fruit, the Strawberry-Raspberry,[4] a native of Japan, bearing scarlet fruit of poor quality, and the Chinese Raspberry,[5] a native of China, bearing a small quantity of sweet yellow fruit. None of these forms has proved to be of commercial value.

USES.

A large part of the raspberry crop is marketed in the fresh state, to be used in the home for various culinary purposes. In addition, large quantities are canned with or without sugar. The

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[1] *Rubus innominatus.*

[2] *Rubus ellipticus.*

[3] *Rubus pheonicolasius.*

[4] *Rubus illecebrosus.*

[5] *Rubus xanthocarpus.*

Census Bureau reports that the value of the canned product in 1914 amounted to $1,137,207, of which 48 per cent was packed in New York State, 22 per cent in Washington, 16 per cent in Michigan, 7 per cent in Oregon, 2 per cent in Maryland, 2 per cent in Ohio, and 3 per cent in other States. Fruit thus canned is used largely for cooking and domestic consumption. It is used also by pie manufacturers and by those who make soda-fountain sirups, crushed fruits, and flavoring extracts.

The standard-size can for packing raspberries for the general trade is the No. 2, which should contain at least 1 pound 3 ounces when packed in water without sugar sirup. Large quantities also are packed in No. 10 cans and in barrels.

Raspberries are made also into jams, jellies, and preserves and quantities are used for making essences and extracts. The juice is sometimes expressed and sold for use as a beverage, and it is used also in the making of ice creams and sherbets.

Red and purple varieties are not often dried or evaporated, but large quantities of black raspberries are marketed in this form. Such dried fruit is used by pie establishments and also by housekeepers in sections of the West where raspberries are not grown.

Brief directions for utilizing raspberries follow. For detailed information, see United States Department of Agriculture Bulletin 196, "Methods Followed in the Commercial Canning of Foods," and Farmers' Bulletin 203, "Canned Fruit, Preserves, and Jellies: Household Methods of Preparation."

Canning in tins.—Only cans that have been lacquered on the inside should be used for raspberries. Stems, leaves, and defective fruit should be discarded and the cans then filled with a certain weight of berries. Hot water or hot sugar sirup should be added, the can exhausted, the top inserted and sealed, and the whole can sterilized. The sterilizing process takes 12 minutes at 212° F. If a sirup is added it should be of the right degree of density to bring out the flavor of the particular variety. Usually the density will range from 15° to 50°. A 50° sirup is made by adding 8 pounds 6 ounces of sugar to 1 gallon of water, and a 15° sirup is made by adding 1 pound 7½ ounces to each gallon of water.

Canning in glass jars.—If there is no objection to shrinkage, the berries may be put in the jars, covered with a hot sirup of 15° to 50° density, and then sterilized for 20 minutes at 212° F. The covers should be fastened on immediately after cooking. If jars full of fruit are desired, the berries should be cooked before being packed in the jars and less sirup used.

Making jam.—For making jam the fresh berries may be used when thoroughly mashed or they may be left whole. If they are used without mashing, some water must be added before cooking, and the cooking will take longer than if no water is added. Ordinarily sugar equal in weight to the berries should be added before cooking. If the fruit is very acid more sugar should be used; if they are mildly acid less sugar will be needed. The jam should be cooked at 212° F. for 20 minutes or until it is the desired thickness and then placed in jars and sealed.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE OF INTEREST IN CONNECTION WITH THIS BULLETIN.

AVAILABLE FOR FREE DISTRIBUTION.

The Home Fruit Garden: Preparation and Care. (Farmers' Bulletin 154.)

The Propagation of Plants. (Farmers' Bulletin 157.)

Cranberry Culture. (Farmers' Bulletin 176.)

Pruning. (Farmers' Bulletin 181.)

Canned Fruit, Preserves, and Jellies: Household Methods of Preparation. (Farmers' Bulletin 203.)

Grape Propagation, Pruning, and Training. (Farmers' Bulletin 471.)

Blackberry Culture. (Farmers' Bulletin 643.)

Manufacture and Use of Unfermented Grape Juice. (Farmers' Bulletin 644.)

Strawberry Growing in the South. (Farmers' Bulletin 664.)

Muscadine Grapes. (Farmers' Bulletin 709.)

Muscadine Grape Sirup. (Farmers' Bulletin 758.)

Home Canning by the One-Period Cold-Pack Method. (Farmers' Bulletin 839.)

Home Canning of Fruits and Vegetables. (Farmers' Bulletin 853.)

Commercial Evaporation and Drying of Fruits. (Farmers' Bulletin 903.)

Directions for Blueberry Culture, 1916. (Department Bulletin 334.)

Factors Governing the Successful Shipment of Red Raspberries from the Puyallup Valley. (Department Bulletin 274.)

Methods Followed in the Commercial Canning of Foods. (Department Bulletin 196.)

The Common Red Spider. (Bureau of Entomology Circular 104.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE.

Insects Injurious in Cranberry Culture. (Farmers' Bulletin 178.) Price, 5 cents.

Strawberries. (Farmers' Bulletin 198.) Price, 5 cents.

Fungous Diseases of the Cranberry. (Farmers' Bulletin 221.) Price, 5 cents.

Possibilities and Need of Supplemental Irrigation in the Humid Region. (Yearbook Separate 570.) Price, 5 cents.

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ADVICE TO FOREST PLANTERS IN THE PLAINS REGION

SEWARD D. SMITH

FARMERS' BULLETIN 888

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Forest Service
HENRY S. GRAVES, Forester

Washington, D. C. October, 1917

Show this bulletin to a neighbor. Additional copies may be obtained free from the Division of Publications, United States Department of Agriculture

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ADVICE about tree planting to provide a windbreak and a supply of firewood, fence posts, and wood for repairs should be especially valuable to the settler in the Plains region.

This bulletin gives advice that will enable him to select the species of trees that will bring the most profitable returns without overburdening him with care.

Following the description of each species of tree adapted to the region, the points to be avoided in connection with its planting are summarized in a few concise " dont's."

Information and advice also are given regarding time for planting, methods of cultivation, pruning, etc.

ADVICE TO FOREST PLANTERS IN THE PLAINS REGION.

CONTENTS.

	Page.
Objects of planting	3
The region	4
Choice of species	4
Species recommended for planting	5
Mixed plantations	13
Ornamental planting	14
Details of planting	15
Methods of planting	16
Time of planting	17
Spacing	17
Cultivation	19
Thinning	20
Pruning	21
Protection	22
Where to secure trees and seed	24
Don'ts for tree planters	24

OBJECTS OF PLANTING.

TREES and shrubs about the home and farmstead not only increase the value of the property, but make conditions pleasanter and more healthful. A limited amount of planting may be done, therefore, for comfort alone irrespectice of other return. Where a considerable plantation is contemplated, however, it is essential to know what material may be grown economically and the uses to which it may be put.

On the average farm in the plains region the first effort in planting is to provide a small grove or plantation which will protect the buildings from severe winds and furnish shade for greater comfort of both man and animals. Sometimes when such a windbreak has been established the owner tries to make it furnish a supply of material for use on the farm. This is a mistake, for if a belt of trees is planted primarily as a protection against the wind the pruning and removal of much large material may lessen or even destroy its protective value.

The value of a plantation, other than a windbreak, on the farm lies in its ability to furnish fuel, posts, and a limited amount of lumber and repair material. Within a very few years after planting, the plantation will need to be pruned and the pruning will furnish considerable fuel, depending upon the size of the plot. If good care is given the trees, they will develop rapidly, and some thinning will have to be done to prevent harmful crowding. The material thus removed will contribute materially to the upkeep of the farm by furnishing posts and stakes. When the plantation is still older, more valuable material may be harvested. Small timbers for building construction, poles for implements, also tool handles, neck yokes, eveners, whiffletrees, and, in favorable situations, a limited amount of lumber is provided at home as needed.

THE REGION.

The species listed in this bulletin are in general suitable for the plains region in the eastern parts of Montana, Wyoming, Colorado, and New Mexico, the western portions of the Dakotas, Nebraska, Kansas, and Oklahoma, and the northern part of Texas. The land in this region is comparatively level and is cut by occasional streams or stream beds marked by limited tree growth, which decreases as one goes westward toward the head of the streams until the mountains are reached. The altitude varies from about 1,500 feet in the east to 5,500 feet in the west. The soil is comparatively uniform and for the most part has good depth and fertility, so that it lends itself to tree culture if proper care is given.

There is, of course, a difference in the rate of tree growth at the extreme limits of the region, but this is due more to difference in the length of growing season than to conditions of soil and moisture. Aridity and temperature are the main factors which determine the success or failure of plantations in the plains regions. Any species which will endure the extremes of these occurring in any part of the plains may be recommended for general planting in the region. For convenience in listing the species suited to each portion the region is divided into the northern and southern parts by the fortieth parallel, which forms the boundary line between Kansas and Nebraska.

CHOICE OF SPECIES.

Throughout the plains region there is a marked scarcity of timber which will produce even a fair grade of lumber, and this fact should be taken into account when species are selected for planting. When a large plantation is established, care should be taken to put out such trees as will give the maximum amount of body material and to arrange them so as to derive the greatest benefit.

In windbreak planting the best results usually are secured when the shortest trees are placed on the side facing the wind, so that a sloping face is presented and the air currents are deflected upward. These short trees should have low-branching habits and dense foliage, in order that they may offer as much hindrance to the passage of air currents close to the ground as is possible. The Russian olive is probably the best for this. Not infrequently, when complaints are made of the reputed ineffectiveness of windbreaks, it develops upon examination that the planter has either used unsuitable species and given them poor care or has failed to establish belts of sufficient width.

It should be understood that the species herein recommended for the plains region are not the only ones which may be grown. They are selected because, under the normal conditions in the plains, they will make reasonable growth without a burdensome amount of care. Of course, a certain amount of moisture and cultivation is necessary for any species, and if it is not given failure will result.

SPECIES RECOMMENDED FOR PLANTING.

NORTHERN REGION.

The northern half of the plains region, which includes the eastern portions of Montana, Wyoming, and Colorado, and the western portions of the Dakotas and Nebraska, is characterized by lower temperatures, heavier precipitation, and a shorter growing season than the southern half. The species recommended for it are as follows:

HARDWOODS.

Hackberry (*Celtis occidentalis* Linn.).—The hackberry is one of the hardiest of the native trees in the plains region, and often thrives under severe conditions. It deserves much wider use in plantations than it now gets. Hackberry associates readily with elm and ash and is recommended for planting in mixture with either. When it is planted alone, the leaves, which are not so tough as those of the elm, suffer considerably from whipping in the wind.

In form and general appearance it resembles the common elm, but is much more hardy and suffers less from insects, except in the Southwest. By nature, the hackberry develops into good form, which makes it highly desirable either for a timber tree or for use in the yard or street.

It seeds very sparingly, so that planters desiring to try it will do well to purchase thrifty stock from reliable nurserymen. It is adapted to a wide range of soils, but makes its best development in moderately moist, loamy, or sandy soils. It should not be planted in alkali soils.

The wood is harder than cottonwood and makes good poles and small construction timbers, but should not be used in contact with the soil without preservative treatment.

Honey locust (*Gleditsia triacanthos* Linn.).—Since the introduction of honey locust from the northeastern States into the plains region of the West it has made a good record as a hardy, rapid-growing, general-purpose tree for wood-lot, street, or yard planting. It is drought resistant and is noted for its endurance of extremes of temperature, which makes it particularly valuable for planting in the northern region. It is suited to a variety of soils and may be planted very successfully on the dry upland areas.

Some objection is made to its heavy thorns, but these may be pruned off easily. It may be readily pruned into a hedge, in which case the thorns may be desirable. Some nurserymen are now supplying a thornless variety which is declared to be equally hardy.

The wood is more valuable for posts and fuel than for larger material. Without preservative treatment it is recommended for posts only in the drier soils. With cultivation it endures close crowding until the crowns shade the ground, and it will produce fully as much material as the elm or hackberry.

White elm (*Ulmus americana* Linn.).—The elm is very popular, and deservedly so, since it is a native tree and does well under cultivation. It thrives in a heavy soil but can not be recommended strongly for sandy areas. In many sections of the plains it is making good growth both on the uplands and on the river bottoms.

The tree is subject to occasional defoliation by insects. These, however, are easily controlled by means of insecticides, and in some cases the trees make good the damage unaided, all of which recommends it for general planting. This species usually makes its best development when planted alone in a protected place but also does well if planted in mixture, since its rapidity of growth soon enables it to overtop the others. For windbreaks it is recommended strongly because of its toughness, which prevents its being broken readily in storms, and because its foliage is exceedingly resistant to the damaging effects of wind.

In a large plantation one can not afford to overlook this tree, since its long life and freedom from disease combine to furnish a continual supply of useful material for the farm. It is better suited to making small timbers and tool handles than posts. Even with preservative treatment it is not the most desirable for fence posts.

Recent importations of foreign trees include the Chinese elm,[1] which is very hardy and a much more rapid grower than the common elm, but as yet the commercial nurseries are not ready to furnish this species.

Don't use the American elm for posts if you can grow honey locust.

Don't attempt to prune it into a hedge.

Cottonwood (*Populus deltoides* Marsh).—Of all the poplars the cottonwood undoubtedly is the most common, and it grows naturally in moist situations on the plains. It can not be recommended for upland planting; but on sites which are favored with a small amount of moisture, even if at considerable depth, it will justify planting.

It makes its best development when not closely crowded, but produces the maximum amount of material when set out in plantations, either alone or in mixture with other species.

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[1] *Ulmus pumila* Linn.

All the poplars are relatively short-lived and often in a short time their appearance is marred by the persistence of numerous dead branches. For this reason alone the planter should go slow in using cottonwood for street or yard planting. There is considerable prejudice against cottonwood trees because of the winged seed or so-called "cotton," which is scattered by the wind in the spring and early summer when the seed is ripe. Only the pistillate (female) plants produce this cotton, which has made it possible for some nurserymen to charge fabulous prices for staminate (male) plants and advertise them as "cottonless" cottonwood. The tree is raised easily from cuttings, and when the scion is taken from the staminate trees (which do not bear seed) the trouble from the flying seed will be avoided. Not infrequently it is cheaper and more satisfactory to dig seedlings from the river bank or to make cuttings from the staminate trees found there than to purchase them in the open market.

Cottonwood, without doubt, is the most rapid-growing tree in the region; and if the planter does not care to wait for material from the more desirable trees, such as honey locust or hackberry, cottonwood should be used. In regions where hailstorms are frequent and severe considerable damage is often done to the tender bark of the younger trees.

For the rapid production of fuel this tree can not be excelled. It also furnishes a fair grade of building material, but the lumber will warp if exposed to the weather. The most common use of cottonwood is for bridge planking and stall partitions. It is of little value for posts unless treated with preservative.

Don't plant cottonwood on high, dry land.

Don't plant cottonwood for a long-lived tree.

Don't plant pistillate (female) plants if you object to the "cotton."

Don't use cottonwood in the soil without preservative.

Don't plant cottonwood singly or in the open if you want quick returns.

Narrow-leaf cottonwood (*Populus angustifolia* James).—The most widely known of the poplars, except the common cottonwood, cultivated in the plains region is the narrow-leaf cottonwood. It is a native of the plains from Canada to Colorada and is found most plentifully along the stream banks and in moist soils, where it attains its best development. Popularly speaking, it is very little different from the common cottonwood, with which it frequently associates. It does not grow to so large a size as the common cottonwood.

The wood is soft and suitable mostly for planking and rough indoor construction work.

White poplar (*Populus alba* Linn.).—The white poplar (the silver-leaf poplar) was introduced into this country from Europe, but has become naturalized through cultivation. It is a rapid grower and rather hardy, but is recommended for ornamental or windbreak planting only. It will not endure the rough usage sometimes given the common cottonwood. The tree always is noticeable because of the white, velvety appearance of the leaves, which are conspicuous whenever disturbed by the wind.

It has no value for lumber or posts.

White willow (*Salix fluviatilis* Nutt.).—The white willow, sometimes called the long-leaf willow, is the most widely distributed of the trees of this genus. Like the cottonwoods, to which it is closely related, it makes its best development in or near stream beds where the supply of water is constant and not very deep. It is used both in windbreaks and for the production of post material. Only in cases where it will receive the best of care is it recommended for upland planting. In the plains region this species seems very hardy within its own range.

It is used more for posts than for other purposes because of its ability to resist decay for a relatively long period. Preservative treatment undoubtedly would lengthen its life in the soil. It is a very rapid grower, but must be planted rather close to produce suitable material in the shortest time.

Don't plant white willow in a dry situation.

Don't fail to plant the trees close together.

Diamond willow (*Salix vestita* Pursh.).—Diamond willow, which partakes more of the nature of a large shrub than a tree, is limited to the northern portion of the region. It is a native of Montana and is very hardy. It has the reputation of making excellent post material, even though rather small. This is one of the numerous varieties of willows extensively advertised by nurserymen as admirably adapted to this region.

Russian olive (*Elaeagnus angustifolia* Linn.).—The Russian olive rarely exceeds 20 feet in height, but despite its shrubby appearance it is one of the hardiest and best trees for both windbreak and ornamental planting. When planted alone, it rapidly develops a dense hedge, and, if not crowded, will spread out close to the ground, a very desirable trait in a hedge plant or windbreak. It is not fastidious in its choice of sites, but its growth is best in soil which is not too moist. It is always helped by cultivation. It is very hardy throughout the plains regions and deserves much more attention than has been given it. Its unique silver foliage adds wonderfully to any situation in which it is planted. It is not recommended for timber production, but will produce a limited amount of fuel.

Don't plant the Russian olive for timber.

Don't plant it on low ground.

Buffalo berry (*Shepherdia argentea* Nutt.).—The buffalo berry is fully as hardy and as beautiful in appearance as the Russian olive. It is, properly speaking, a shrub; but for hedges, windbreaks, and ornamental planting it can not be surpassed. The red and yellow fruit and silvery foliage make a very pleasing combination either when the trees are planted alone or in a compact block. This species is a native of Montana and may be depended upon to give satisfactory results in all the northern portion of the plains. In some sections the fruit is used for domestic purposes.

Don't try to make the buffalo berry produce posts or lumber.

Don't expect it to make a large shade tree.

Siberian pea tree (*Caragana arborescens* Linn.).—Although essentially a shrub, rarely over 15 feet in height, the Siberian pea tree has considerable to recommend it over some of the more common trees. It is very hardy and lends itself readily to planting as a hedge for ornament or windbreak. On the lawn it develops rapidly with little care and makes a very pleasing appearance by reason of its yellow flowers. It is not suited to locations where no water is available.

Don't plant this tree for posts or timber.

CONIFERS.

It is more difficult to obtain successful species for the plains among those trees which hold their leaves over the winter, or evergreens, as they are sometimes called, than among hardwoods. There is a prejudice against conifers, and many people who desire to plant them hesitate because of reputed losses. The roots are very delicate, and exposing them to the sun or wind for even a few minutes will kill the tree, whereas the roots of hardwoods are often exposed for a much longer time without great loss. When people learn to care for the young trees and plant them properly, more conifers will be used. As a rule they are slower growing than hardwoods, but eventually make the more serviceable trees, not only because they are drought resistant when thoroughly established, but because they carry their dark green foliage all the year and give a cheery atmosphere to the landscape during the winter months.

Jack pine (*Pinus divaricata* DuMont de Cours).—Until about 10 years ago very little was known of jack pine, which is native to the sand plains of the Lake States and adjoining territory. It is most at home on these plains, which become very dry, but it will accommodate itself to a great variety of sites except where there is an excess of moisture and the soil is heavy.

Jack pine is being planted extensively in the plains region, and in practically every case it has established an enviable reputation for hardiness and rapidity of growth even under adverse conditions. Several hundred acres are planted annually to this species by the Federal Government in the sand hills of Nebraska, and good results have already been secured. Jack pine does fully as well upon the uplands and sandy land as upon the more fertile bottoms.

It is essential in every case that the tree be protected from heavy grass and sod during the first three years; after that it will care for itself.

Jack pine is a rapid grower, and although not so valuable as western yellow pine is used extensively for windbreaks, posts, poles, and fuel. It is doubtful whether it will ever produce saw timber of any value.

Don't plant jack pine in low wet ground.

Don't plant jack pine to produce large saw timber.

Western yellow pine (*Pinus ponderosa* Laws).—Western yellow pine may be recommended under much the same conditions as jack pine. During the first few years it grows more slowly than jack pine; but this handicap is soon overcome, and at 10 years of age the yellow pine is farther ahead and the tree is much more symmetrical. In the sand hills of Nebraska, where several hundred acres of this species have been established by the Federal Government, there is an increasing demand for it, and it promises to be the best tree for timber production in the region. It may be used in mixture with other species or as a block of pure yellow pine. If not surrounded, it has a tendency, common to most trees, to branch and become scrubby, thus losing its symmetry and much of the real value as a timber producer, which comes only when it is compelled by crowding to make a height growth proportionate to the diameter.

For general service, where beauty, hardiness, and valuable material are desired, this tree is recommended. Posts, poles, and other construction material may be obtained from the smaller trees. The better specimens will furnish a good grade of lumber. The wood is strong and hard.

The pine tip moth[1] ofttimes works considerable havoc by destroying the terminal buds. Where this insect is not present in large numbers, however, this tree makes very good growth.

Don't plant western yellow pine on steep south slopes.

Don't plant western yellow pine singly or without cultivation.

Don't plant western yellow pine where neighboring pines are infested by the pine tip moth.

Don't plant western yellow pine or western yellow pine seedlings or transplants shipped from an infested region or nursery.

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[1] *Evetria bushnelli* Busck.

SOUTHERN REGION.

All the species recommended for the northern portion of the plains region may be planted in the southern portion, which includes southeastern Colorado, western Kansas and Oklahoma, and northern Texas, and on account of the more moderate temperatures it is possible to extend the list. The following additional species are recommended:

HARDWOODS.

Boxelder (*Acer negundo* Linn.).—The boxelder, or ash-leaved maple as it is sometimes called, is the hardiest of the maples and grows rather rapidly; but because of its low, dense branching habit and knotted trunk it is more desirable for windbreaks or plantations than for ornamental use. It does best when planted rather close. It is more adapted to the trying conditions of the plains than the Norway maple,[1] which, although less hardy, is more desirable as a shade tree and is frequently used where a fertile, moist soil is provided.

The boxelder is recommended only for the bottom lands, where there is a heavy soil. It is a mistake to plant it upon uplands and sandy soils.

At its best it is short lived, and the wood has unusually poor value even for fuel. Preference might well be given other species if they can be secured.

Don't plant boxelder north of the Kansas-Nebraska line.

Don't plant it in dry or exposed situations.

Don't plant it on uplands and sandy soil.

Green ash (*Fraxinus lanceolata* Borkh.).—Green ash will endure more severe conditions than the boxelder and is more serviceable in general appearance, rate of growth, and quality of timber. In its native State it is short, with well-rounded head and many crooked branches. It is more desirable for windbreaks or posts and fuel than for ornament unless planted in groups and given considerable care.

During the first year or two the young plants may lose some of their tops through winter killing, but as the trees get older this tendency is overcome. Native-grown trees for planting are preferable to those raised in the more humid regions. The green ash responds quickly to good treatment, and its value as a producer of useful material is largely dependent upon the care given it.

The wood is tough, durable, and straight grained and is considered one of the best of the native woods for fence posts. It is used also for tool handles and in some cases for construction material.

Don't plant green ash on extremely dry sites.

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[1] *Acer platanoides.*

Don't plant it north of the Nebraska-South Dakota line.

Black locust (*Robinia pseudacacia* Linn.).—Were it not for the fact that black locust is often attacked by the locust borer, it doubtless would be planted more generally than any other species in the plains. It makes more than ordinary growth on the uplands and endures the extremes of temperature in the southern plains region to a remarkable degree.

The wood is very durable, even in contact with the soil, and it also possesses great strength and fuel value. The borer[1] attacks trees 2 to 5 inches in diameter, those less than 2 inches being free from injury, while trees 3 to 5 inches suffer most severely. It thrives where there is an abundance of goldenrod, since the adults, or beetles, feed on the pollen of this plant before they are ready to oviposit. The Bureau of Entomology is experimenting with control operations against it on a large scale and will publish the results when these are completed. The scheme followed by some is to establish a plantation every five to eight years, so that the material can be removed before it is large enough for the insects to do much damage.

Don't plant black locust north of the Kansas-Nebraska line.

Don't plant it on pure sand.

Don't plant it where borers are prevalent unless the adoption of remedial measures is contemplated.

CONIFERS.

Red cedar (*Juniperus virginiana* Linn.).—Of all the cultivated varieties of juniper, red cedar probably is the most hardy and satisfactory for this region. Its preference is for heavy or limestone soils and it avoids sandy soils. The great objection to it is that its growth is very slow. This is in part compensated for, however, by the hard, fine-grained wood, which is eagerly sought for fence posts.

In the lawn this tree makes a very pleasing combination with the varying shades of green of other species. It is native to Kansas and Nebraska and gradually is extending itself westward. The red cedar is the longest-lived tree among those suitable for this region, which makes it excellent wherever permanent trees are desired. It gives protection both in summer and winter.

This species should not be planted in the vicinity of an apple orchard. The "cedar apple" fungus, which is one stage of the apple leaf spot, may infect apple trees even at a considerable distance. When planted alone and in much exposed places red cedar should not be pruned.

Don't plant red cedar on pure sand.

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[1] *Cyllene robinæ* Forst.

Don't plant red cedar near an apple orchard.

Don't plant red cedar if you want a quick-growing tree.

Chinese arborvitæ (*Thuya orientalis* Linn.).—Unlike our native American arborvitæ the Chinese arborvitæ thrives on heavy upland or limestone soils. It is not a large tree, but its small size is more than offset by its hardiness and luxuriance of growth. It is admirably adapted to windbreaks and decorative planting about the home, either singly or in mixture, but is not to be relied upon for the production of timber. It is an importation and little is known concerning its behavior in old age, but its hardiness appeals to the home builder in this region.

Don't plant Chinese arborvitæ on sandy areas without heavy soil below.

Don't plant this species if you want timber.

MIXED PLANTATIONS.

Plantations containing two or more species in mixture are so few and of such recent planting that it is not possible to refer to them as examples, but sufficient evidence has been collected to show that under certain conditions it is preferable to plant certain species together. It may be that one species has a very scant foliage and another is needed to make a crown cover sufficiently dense to shade out the grass and weeds after cultivation has been stopped; or it may be advisable to plant a long-lived species with one which comes to early maturity, so that the quick-growing species may furnish material and then have its place filled by the slower-growing species. If consideration is given to this when the plantation is established, a better class of material will be secured and less care will be required to produce it. It is, of course, much more important if posts and lumber are to be grown than if a windbreak is the primary object. When conifers are used, hardwoods often may be planted with them, thus reducing the initial cost of the plantation.

Below are given a few species which may well be planted together:

Honey locust with hackberry.
Honey locust with jack pine.
White elm with hackberry.
Black locust with yellow pine.
Black locust with red cedar.
Green ash with honey locust.
Cottonwood with green ash.
Yellow pine with jack pine.

For windbreaks any of the following groups may be used, the first-named species being placed on the side from which the prevailing winds come. At least two rows of each species should be used.

Russian olive.
White elm.
Hackberry.
Cottonwood.
Jack pine.

Russian olive.
Hackberry.
Honey locust.
Yellow pine.
Russian olive.

Green ash.
Honey locust.
Cottonwood.
Red cedar.

ORNAMENTAL PLANTING.

Very frequently a demand exists for trees or shrubs which are adapted primarily to ornamental or decorative planting in lawns, parks, and cemeteries where it is possible to furnish abundant water, cultivation, and some protection in winter. The following are suggested as suitable in this region for such purposes. It should be understood that these species will not thrive unless considerable care and protection are given them.

White birch (*Betula papyrifera* Marsh.).—Characterized by its white bark and rich green, drooping foliage.

Weeping birch (*Betula papyrifera* var. ————?). A variety of white birch, but with smaller leaves and pendulous branches.

Basswood (*Tilia americana* Linn.).—A rapid growing tree with large, rich green leaves. The delicate white flowers are very fragrant.

Soft or silver maple (*Acer saccharinum* Linn.).—Of all the hardwoods planted in our lawns and parks silver maple is probably the most widely used, with the possible exception of white elm. It is, however, not entirely satisfactory. The limbs are very brittle and are often broken off by the wind. It is a rapid grower; but the new growth is sometimes killed back at periods of low temperature, and the dead limbs mar the otherwise pleasing appearance of the tree.

Hardy catalpa (*Catalpa speciosa* Warder).—Hardy catalpa demands rich soil and the best attention; but the wealth of blossoms in July, when most of our other trees are out of flower, compensates to a certain exent for the extra care. It is very sensitive to low temperature. Because if injudicious advertising this species has been introduced into regions where it can never be expected to give satisfaction.

Black walnut (*Juglans nigra* Linn.).—Black walnut is familiar to nearly every one through the edible fruit or nuts. The tree is a rapid grower, but furnishes only a limited amount of shade. The brittle branches are often broken in the wind.

Bur oak (*Quercus macrocarpa* Michx.).—In certain favorable locations on the plains, possessing rich soil and considerable moisture, bur oak may be grown, but it is a slow grower and will develop into scarcely more than a shrub. It will thrive in well-cared-for lawns, but can not be recommended for general plains planting.

Sycamore (*Platanus occidentalis* Linn.).—The plane, or button-ball tree, as it is sometimes called, is conspicuous on account of its green and white mottled bark and the small rounded heads, carrying the seed, which remain on the tree over winter.

Horse chestnut (*Aesculus glabra* Willd.).—The horse chestnut, noticeable by reason of its peculiar leaves and richly colored blossoms, is used where considerable contrast is desired. It is too large a tree for small lawns and sometimes is objected to on account of the fruit and numerous pods which cover the ground in early fall.

Mountain ash (*Sorbus americana* Marsh).—A relatively hardy ornamental tree, with well-developed crown and bright orange-colored berries, which persist until late in the fall.

Barberry (*Berberis thunbergia* D. C.).—A hardy shrub, made noticeable in the summer by its yellow flowers and in the winter by the bright red berries, which are long persistent.

Purple barberry (*Berberis vulgaris atropurpurea* Linn.).—Similar to green barberry, but marked by rich purple leaves.

Douglas fir (sometimes called red fir, red spruce, or Douglas spruce) (*Pseudotauga taxifolia* (Lam.) Britton.).—A rapid-growing conifer, excellent for lawns and for group planting in parks and similar areas. A wide range in colors makes it very popular for landscape work.

Colorado blue spruce (*Picea parryana* Sarg.).—A hardy conifer in a rich, moist soil and very conspicuous for its rich, bluish-green foliage. Grows much more slowly than Douglas fir, but is extensively used where pleasing landscape effects are desired.

White fir (*Abies concolor* Lindl. & Gord.).—A moisture-loving conifer in much the same class as blue spruce, but with a lighter foliage. Needles are long and flattened instead of square and pointed, as with the spruce. The white fir is adapted more to the northern portion of the region.

DETAILS OF PLANTING.

CHOICE OF PLANTING STOCK.

A plantation established with poor stock always is handicapped. The purchase of cheap stock, simply because it is cheap, is poor economy, for often it results in failure.

Fortunately, most of the hardwoods may be grown easily from seed, and the possibility of buying stock which is not true to name or of having it injured in transit avoided. If the farm maintains a garden plot, the hardwood seedlings may be grown there and planted out in the field when one year old. The seed of the desired species may be purchased or collected locally, sown in rows, and handled much the same as vegetable seed. The plants should be watered and cultivated, so that they will become as large as posisble during the season. After the first of September water should be applied only to keep the ground from drying out completely. This is necessary in order to harden the tender wood to withstand frost.

Cuttings may be used successfully for growing the planting stock for such trees as willows and cottonwoods. These cuttings, which are best made in the fall or early winter after the leaves have fallen, should be about 10 inches in length and taken from 1-year-old or 2-year-old twigs of vigorous, healthy trees. Cuttings should be made always with slanting strokes of a very sharp knife, so as to avoid bruising the bark. If trees free from seed, or "bloom," as it is sometimes called, are desired, cuttings should be taken from trees which observation has shown do not produce seed. As soon as the cuttings are made they should be tied in bundles of about 50 and buried in cool, moist, well-drained sand until spring. As soon as possible in the spring, and always before the soil dries out, the cuttings should be set out, with the buds pointing upward, leaving two or three inches above ground. The soil should be pressed firmly about the stems, and if it is not soft it is better to make holes for the cuttings with a round bar or dibble.

Trees grown from large nuts, such as walnut and oak, are best propagated by planting the nut where the mature tree is desired. Unless this is done, the long, heavy taproot, even at the end of the first year, makes transplanting difficult and the loss heavy. Black walnut is best planted in the fall.

Conifers are much more difficult to raise than hardwoods, and unless a large project is undertaken it is inadvisable to attempt to raise them. Thrifty stock may be purchased from reliable nurserymen and in some cases at cost from nurseries maintained by the State. Stock grown as near as possible to the region of planting is always preferable.

If hardwoods are used, 1-year seedlings give best results under normal conditions. Large stock should be avoided. It is more expensive and requires more time and attention to plant. If conifers are used, nothing smaller than 3-year-old transplants should be tried. Transplants are preferable to seedlings because of the larger mass of fibrous roots.

METHODS OF PLANTING.

Planting methods are dependent largely upon the size of the stock and the condition of the site. When stock is received for planting, the first precaution is to see that it has not dried out. The roots never should be exposed to the sun or drying air. The roots of stock that is packed in crates should be moistened thoroughly before the trees are removed. If the trees are extra-large conifers and the roots of each tree are protected with earth bound with a cloth covering, the whole should be planted without removing the wrapper. In any case, all small stock, if it can not be planted at once, should be heeled in in a cool, moist situation. The tops should not be covered.

All grassy, weedy, or heavy land should, if it is practicable, be plowed and harrowed at least 12 months before the trees are planted. Fall plowing is preferable. If manure is to be used, it should be applied at the time of plowing to enable it to decay. If it is placed fresh next to the roots at the time of planting, there is danger of "burning" them. Although plowing is not absolutely necessary, it is productive of good results, and the benefits are several times as great as those secured by caring for the ground after the stock is set out. It is still better to use ground which has been under cultivation for two or three years. Young plants need just as much care as a garden, and their growth will be proportionate to the amount of care they receive.

Planting may be done in either of two ways: By the slit method or by the individual-hole method.

Either of these methods may be worked out in a shallow furrow. It is very desirable on sod ground to plow a furrow if complete cultivation of the planting area can not be carried out. This will remove the grass cover and will make the work much cheaper. All sod or grass cover should be removed from a space at least 15 inches square before a tree is planted, provided it is not set in a furrow.

SLIT METHOD.

The slit method is the cheapest and in light, sandy soils the best. A spade is used to open a wedge-shaped hole in the ground by moving it forward and backward. Into this opening the tree roots are suspended full length, and the earth is pressed firmly around them by a thrust of the foot which closes the hole.

DEEP-HOLE METHOD.

A hole is dug wide enough and deep enough to accommodate the tree roots without crowding. Care should be exercised in putting the soil back on the roots to see that no large rocks or sods are allowed to fall in, because of the possibility of leaving air spaces, which will cause the plant roots to dry out. Holes never should be dug a long time in advance of planting, unless it be in the fall, on account of the danger of drying out. If there is a hardpan or stratum of soil impervious to water at the bottom, this should be broken up thoroughly with tools or a light charge of dynamite. Unless this is done the tree will not thrive.

TIME OF PLANTING.

Planting should be done in the spring. The best results are secured from the earliest planting. This rule has no exception in the plains region. Fall planting may be advisable in certain cases where it is possible to give each tree individual attention, but in every case where general planting has been done after the growing season has passed failure has resulted. When trees are planted in the spring, they have the advantage of a full summer's growth and the accummulated winter moisture, and the liability of loss from winter heaving caused by alternate freezing and thawing is slight. It is also a decided advantage if the planting can be done on damp, cloudy days, thus affording the tender roots protection from the hot sun and wind.

SPACING.

The amount of cultivation to be given a plantation determines to a certain extent the spacing of the trees. If the plantation is nearly square, room may be made for working a cultivator both ways by setting the trees in the rows the same distance apart as the rows, but if a long, narrow windbreak is being developed it is doubtless preferable to have the trees close together in rows that are far enough apart to allow cultivation to be carried on for several years. A spacing of 2 by 8 feet will give the same number of trees per acre as a 4 by 4 spacing, and will provide for a much longer period of cultivation. The aim should be to keep the ground free from weeds. If the trees are not close enough to accomplish this, cultivation must be practiced, and the spacing should provide for sufficient room for a team and tools to pass easily without injuring the bark of the trees or breaking off the limbs. The tendency is to set the trees too close rather than too far apart. In general, the rule is that a wide spacing with frequent cultivation is productive of better results in the arid regions than close spacing and less frequent cultivation. However, on those farms which are favored with river bottom land the trees should be spaced much closer, since the yield will be greater and the trees will be better formed. In plantations closely spaced some of the smaller or stunted specimens may be thinned out and used for fuel or posts if the trees begin to crowd each other too much.

It is much easier to plant trees for protection from the wind or for the production of posts and fuel than to make a combination of the two, because the removal of much material may lessen the value of the windbreak unless it is very large and planned to furnish other products. If it is desired primarily to grow posts or similar material, the lower branches must be pruned off and the worthless trees cut out, which results, of course, in less obstruction to the wind and very little protection from it unless the planted area is of considerable size. If a windbreak is most desired, the trees should be spaced much more closely in the row without so much consideration for size, in order that the branches filling up between the rows may reach the ground, shade out the weeds and grass, and make a dense shelter and an effective hindrance to the wind. A spacing of 2 by 8 feet gives good results in a windbreak, if the trees are arranged alternately in the rows, but for a timber or post plantation most trees may be set 8 by 8 or 10 by 10 feet and cultivated carefully.

TABLE 1.—*Spacing and soils best adapted to each species and products from each kind of wood.*

Species.	Spacing.	Most suitable soil.	Products obtainable in—		
			5 to 10 years.	20 to 25 years.	Over 50 years.
Hardwoods:	*Feet.*				
Honey locust	10 by 10	Heavy loam	Small posts. Cordwood.	First and second class posts. Stakes. Cordwood.	
Hackberry	8 by 8	Light or heavy soils, if not low.	do	First and second class posts. Cordwood.	Lumber, timbers.
White elm	8 by 8	Wide range light to heavy. Moderately moist.	do	do	Lumber.
Black locust	8 by 8	Dry upland	do	do	Posts and timbers if not destroyed by borers.
Green ash	8 by 8	Moist loam bottom lands.	Cordwood	do	Lumber.
Boxelder	8 by 8	Bottom lands. Avoid sand or uplands.	Small posts and stakes. Cordwood.	First and second class posts.	Posts.
Cottonwood	10 by 10	Moist bottom land	Posts. Cordwood.	First and second class posts. Cordwood. Narrow lumber.	Lumber.
Willows	8 by 8	Prefers moist loamy soils. Heavy uplands if well cultivated.	Small posts and stakes.	First and second class posts.	
Russian olive	4 by 8	Thrives on dry uplands.	Windbreaks, ornament, and hedges.	Windbreaks, ornament, and hedges.	
Buffalo berry	2 by 8	Moderately dry soils.	Ornament and hedges.	Ornament and hedges.	
Siberian pea tree.	4 by 8	Moist loamy soils.	Hedges, windbreak, and ornament.	Hedges, windbreak, and ornament.	Hedges, windbreak, and ornament.
Conifers:					
Jack pine	6 by 8	Sandy soils. Avoid heavy and very moist soils.	Windbreaks	First and second class posts. Cordwood.	
Yellow pine	6 by 8	Endures more moisture than jack pine.	do	do	Lumber.
Red cedar	4 by 8	Heavy or limestone soils.	Windbreaks and hedges.	First and second class posts.	First and second class posts. Windbreaks.
Chinese arborvitæ.	4 by 8	do	do	Hedges and ornament.	

TABLE 2.—*Number of trees per acre with various spacings.*

Spacing. Feet.	Number of trees.	Spacing. Feet.	Number of trees.
3 by 3	4,840	5 by 8	1,089
3 by 4	3,630	6 by 6	1,210
3 by 5	2,904	6 by 8	907
3 by 6	2,420	6 by 10	726
4 by 4	2,722	8 by 8	680
4 by 5	2,178	8 by 10	544
4 by 6	1,815	8 by 12	453
4 by 8	1,361	10 by 10	435
5 by 5	1,742	10 by 12	363
5 by 6	1,452	10 by 15	290
5 by 7	1,244	15 by 15	193

CULTIVATION.

Cultivation is just as necessary in establishing a successful plantation of trees as in other lines of agriculture, and the results are proportionate to the amount of labor expended in keeping the soil loose and free from weeds. It is a mistake to suppose that trees can be grown in a weedy or grassy area without some cultivation or protection from the more rapid growing plants. If a quick, healthy growth is desired, there is no more certain way of insuring it than to cultivate. No other factor goes so far toward lessening the loss resulting from insufficient moisture. To be most effective, cultivation should be begun at least one year before the trees are planted.

A large proportion of failures in plantations are caused by the negligence of the planters. Some even go so far as to argue that native trees receive only the care that nature gives, and therefore it is only necessary to plant them and they will care for themselves. No greater mistake can be made. Trees, the same as other plants, need attention if they are to do well; and cultivation, which has for its object the prevention of the growth of weeds and grass and the conservation of moisture, encourages the growth of the tree most effectively.

Cultivation should be shallow. The roots of many trees run close to the surface of the soil, and if these are injured by cultivation the tree may be stunted in its growth.

Cultivation should take place as soon as possible after each rain. This forms a dust mulch, which is the best means of saving the moisture already in the ground.

Cultivation should not be continued after the middle of July. This is to prevent the development or growth of new wood late in the season which may be injured by severe, early frosts. The danger from this source is greater than is realized ordinarily; oftentimes hardy young trees are killed back to the ground following late cultivation and irrigation.

Don't let the weeds get so high that a plow must be used to destroy them. They rob the trees of moisture, and the plow will injure the fine tree roots.

THINNING.

The object of thinning is to rid the stand of those trees which, because of either their unhealthy condition or crowded position, are retarding the growth of the more desirable individuals. The principle is the same as in other crops which are thinned to promote the best development of a portion rather than a poor growth of the entire crop. When trees are young, they are very sensitive to conditions around them, and if they are crowded the tendency is toward a stimulation of growth and an improvement in quality in the thriftier individuals and a failure in the poorer class. This process, which is entirely natural, disposes of a great many of the weaker trees, but if continued too long may stunt some of the best trees. It is at this stage that thinning becomes a necessity and the weak and deformed individuals are removed.

Need of thinning is indicated when there are many dead or dying trees in the stand, or when the trees are very slender in proportion to their height. A stand in need of thinning often has the crowns of all the trees densely matted or so closely interlocked that growth apparently has ceased. If the condition of the stand is such that the growth will not be lessened, it is more satisfactory to postpone the thinning until there is enough merchantable material to pay for the cost of removing it from the stand. The first thinning will yield fuel and small posts, and if the poorer material is removed each time each subsequent thinning will yield bigger and better material. Care should be be exercised not to remove so much material that the sunlight will induce a sod cover under the trees. The opening in the tops should close in three or four years. The fact should not be overlooked that in a large grove or plantation the shade afforded by the dense crowns of the trees takes the place of cultivation in keeping the grass down and lessening the evaporation of water from the soil.

More care is necessary in thinning a windbreak or a plantation with rows wide apart, but trees spaced closely in the rows, than in removing crowded material from a stand evenly spaced both ways. Trees planted in wide rows always have a chance to branch toward the opening between the rows, thereby relieving themselves of the crowding in the row, and when any tree is removed from the row there is crowding from only two sides to fill the crown space. Less crowding gives the poorer trees more of a chance, necessitating better judgment in removing from the crowded row inferior trees which in an entirely closed plantation would be killed out by natural means.

PRUNING.

Pruning is the removal of some portion of a living tree and its purpose may be—

(*a*) To dispose of dead or diseased material.
(*b*) To renew or stimulate growth.
(*c*) To modify the form of the tree.

This operation, which is essential to the best growth and development of a tree, never should be done carelessly.

If it is desired to produce a stem free from branches, the young tree should be pruned gradually and a very few of the lower limbs removed each year. In order to have a well-developed stem the crown must be sufficient to produce the material. The tendency of the average person is to prune either too much or not at all. On young trees the pruning may be carried too far up the stem, so that the tree becomes top-heavy and is deformed or broken off in the first storm.

Pruning is practiced most often to modify the form of a tree, but in many cases it is necessary in order to induce production of merchantable material. Some species, like the boxelder or black locust, may sprout freely from the root collar, and unless the sprouts are removed promptly the new growth will pass into them and several small stems will develop rather than one large one. Such trees as the honey locust and white elm have a tendency to branch too near the ground. By removing the lower limbs a longer, straighter merchantable stem will be produced.

Carelessness in pruning is manifest usually in the rough knots and stubs left wherever the limbs are cut off. These scars and broken surfaces make a breeding ground for wood-rotting fungi; and through them decay may reach to the heart of the tree, causing it to die or break off, or may produce a cavity in the stem, making it almost worthless. Pruning always should be done with sharp tools to avoid a bruised surface, and as little of the limb should be left as possible. The cut should be even with the main stem. In removing large, heavy limbs there is always danger of the limb tearing the bark on the underside. This may be lessened by making two cuts in the branch, one on the underside of the limb near the tree and the other on the upper side 15 or 20 inches beyond the lower. When the limb has dropped the remaining stub may be cut close to the trunk. Water and fungus spores may be kept out of fresh wounds or cuts by applying common lead paint immediately.

Pruning may be done at any season of the year, if care is exercised; but the danger of separating the bark from the body is least if the pruning is done in fall or winter, when the tree is dormant and the sap is not flowing. About one-third of the top and branches of a hardwood should be cut back when the tree is set out.

PROTECTION.

Grazing animals never should be allowed to use the plantation as a pasture. The trees are damaged, reproduction either by seed or sprouts is made impossible, and the continued trampling tends to make the ground hard and dry, thus robbing the trees of the moisture which they always need.

Fire also is an enemy of the plantation, and unless the trees are otherwise guarded fire lines from 5 to 6 feet wide should be plowed around the area and kept free from grass and weeds as long as there is danger from this source.

Cropping the plantation is a fruitful source of loss. Crops should not be planted between the rows, unless it be small truck for one or two years. If the soil is so rich or moist as to permit the handling of crops between the rows, it would be better to plant more trees per acre.

Some loss is occasioned by rabbits and pocket gophers. Rabbits may be destroyed by poisoning with strychnine solution sprinkled upon alfalfa leaves and distributed along frequented runways or about feeding grounds. Care must be taken, however, to safeguard domestic animals from this poison. Pocket gophers may be poisoned by sprinkling a mixture of strychnine and saccharine upon cubes of sweet potatoes, carrots, or beets, which are then inserted into the underground runways. The Bureau of Biological Survey, Washington, D. C., has made extensive studies of methods of destroying rodent pests, and should be consulted to obtain specific instructions regarding their eradication.

Insects may cause serious damage, and where the attack is severe aid should be sought from the Bureau of Entomology, Washington, D. C., or from the experiment station maintained by the State, specimens of the insects or their work, or both, being forwarded whenever possible.

WHERE TO SECURE TREES AND SEED.

A list of dealers handling tree seed and nursery stock will be furnished free of charge upon application to the Forest Service, Department of Agriculture, Washington, D. C.

DON'TS FOR TREE PLANTERS.

Don't plant on ground poorly prepared.
Don't plant on raw, new, or soddy ground.
Don't buy a poor grade of stock. Consult several nurseries.
Don't plant late in the spring. Early work gives best results.
Don't allow plants to become dry.
Don't dig shallow holes. Loosen up the soil.
Don't dig small holes. Tree roots must not be cramped.
Don't put grassy sods in a hole. Air spaces will kill the tree.
Don't put manure in direct contact with tree roots.
Don't plant carelessly. You are working for the future.
Don't trim conifers when planting.
Don't plant hardwoods without cutting back one-third of the top.
Don't fail to cultivate thoroughly.
Don't let weeds grow. The trees need the moisture.
Don't rob the plantation by planting other crops in it.
Don't allow any stock within the plantation.
Don't expect a large grove in a year. Trees grow slowly.

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BACK-YARD
POULTRY KEEPING

ROB R. SLOCUM
Animal Husbandry Division

SUPERSEDED BY 1508

FARMERS' BULLETIN 889

UNITED STATES DEPARTMENT OF AGRICULTURE

Jan. 5 1918

Contribution from the Bureau of Animal Industry
A. D. MELVIN, Chief

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Washington, D. C. November, 1917

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IN every household, no matter how economical the housewife, there is a certain amount of table scraps and kitchen waste which has feeding value but which, if not fed, finds its way into the garbage pail.

Poultry is the only class of domestic animals which is suitable for converting this waste material, right where it is produced in the city, into wholesome and nutritious food in the form of eggs and poultry meat.

Each hen in her pullet year should produce 10 dozen eggs. The average size of the back-yard flock should be at least 10 hens. Thus each flock would produce in a year 100 dozens of eggs which, at the conservative value of 25 cents a dozen, would be worth $25.

By keeping a back-yard poultry flock the family would not only help in reducing the cost of living but would have eggs of a quality and freshness which are often difficult to obtain.

Remember that eggs produced by the back-yard flock cost very little, as the fowls are fed largely upon waste materials.

BACK-YARD POULTRY KEEPING.

CONTENTS.

	Page.
Advantages of home poultry	3
Overcoming objections to keeping poultry in the city	4
Kind of fowls to keep	4
Size of flock	5
Procuring stock	5
Housing	7
The yard	13
Feeding	15
Lice and mites	19
Hatching and raising chicks	20
Culling the hens	20
Preserving eggs	21
Practical pointers	22

ADVANTAGES OF HOME POULTRY.

THE keeping of a small flock of laying hens on a town or village lot or in a city back yard is an important branch of poultry keeping. Though the value of the product from each flock is small of itself the aggregate is large. The product of such a flock, both in the form of eggs and fowls for the table, may be produced at a relatively low cost, because of the possibility of utilizing table scraps and kitchen waste which would otherwise be thrown away. A small flock of hens, even as few as six or eight, should produce eggs enough, where used economically, for a family of four or five persons throughout the entire year, except during the molting period of the fall and early winter. By the preservation of surplus eggs produced during the spring and early summer this period of scarcity can be provided

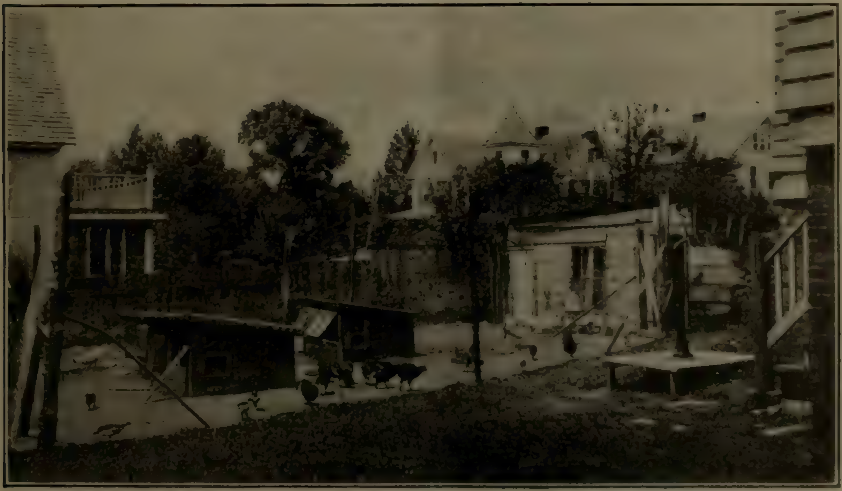

FIG. 1.—Poultry house and run in a back yard.

for. The keeping of pullets instead of hens also will insure the production of eggs at this time. Not only will the eggs from the home flock materially reduce the cost of living, but the superior freshness and quality of the eggs are in themselves well worth the effort expended. Eggs are a highly nutritious food and are so widely used as to be almost indispensable, and an occasional chicken dinner is relished by everyone.

Where conditions render it feasible and cheap small flocks of poultry should be kept to a greater extent than at present by families in villages and towns, and especially in the suburbs of large cities. The need for this extension of poultry raising is particularly great in those sections where the consumption of poultry products exceeds the production, with the result that prices are high.

OVERCOMING OBJECTIONS TO KEEPING POULTRY IN THE CITY.

Objection is frequently raised to the keeping of poultry in towns and cities because of the odor which may result and also because of the noise which is made by roosters crowing, particularly in the early morning. In some cases city regulations have been formulated to prevent or to control poultry keeping. Where there are city regulations it is necessary to find out their provisions and to conform to them. There is no necessity for the poultry flock to become a nuisance to neighbors. If the dropping boards are cleaned daily and the houses and yards are kept in a reasonably clean condition there will be no annoying odors.

The male bird need not be a nuisance. Unless it is intended to hatch chickens from the flock it is unnecessary to keep a male bird. The fact that there is no male in the flock will have absolutely no effect on the number of eggs laid by the hens. If it is desired to mate the hens and to hatch chicks the male bird should be sold or eaten just as soon as the hatching season is over. This is desirable not only for the purpose of eliminating noise, but also to save the feed that would be eaten by the male and for the reason that the eggs produced after the male is disposed of will be infertile. Since these eggs are incapable of chick development they keep much better than fertile eggs and consequently are superior for preserving or for market.

The flock must be kept confined; otherwise the hens will stray into neighbors' yards and gardens, where they may cause damage and are almost sure to cause ill feeling.

KIND OF FOWLS TO KEEP.

Householders usually desire not only eggs for the table and for cooking, but also an occasional chicken to eat. For this reason one of the general-purpose breeds, such as the Plymouth Rock, Wyandotte, Rhode Island Red, or Orpington, is preferable to the smaller egg breeds, such as the Leghorns. Not only do the mature fowls of these breeds, because of their larger size, make better table fowls than the Leghorns, but the young chickens for the same reason make better friers and roasters, whereas chickens of the egg breeds are only suitable for the smaller broilers. The general-purpose breeds are also " broody " breeds, the hens making good sitters and mothers, which is a decided advantage when it is desired to hatch and raise chickens, since the hens of the egg breeds seldom go broody and are in any event rather unreliable sitters and mothers. If, however, the production of eggs outweighs the desire for an occasional table fowl, the lighter egg breeds undoubtedly will be found better, because they lay as many eggs and do so on less feed, with the result that they produce the eggs more cheaply. It is by all means advisable to keep some pure breed or variety. Where this is done, sales at a profitable figure can often be made of breeding stock which it is intended to market or of eggs for hatching.

SIZE OF FLOCK.

The size of the flock which can be most efficiently kept will depend first of all upon the space available and, secondly, upon the amount of table scraps or other waste which is available for feed. It is a mistake to try to overstock the available space. Better results will be obtained from a few hens in a small yard than from a larger number. The back-yard poultry flock rarely will consist of over 20 or 25 hens and in many cases of not more than 8 or 10, or occasionally of only 3 or 4. For a flock of 20 to 25 hens a space of not less than 25 by 30 feet should be available for a yard. Where less space is available, the size of the flock should be reduced, allowing on the average 20 to 30 square feet per bird. A few hens are sometimes kept successfully with a smaller yard allowance than this, but if the space is available a yard of the size indicated should be used.

PROCURING STOCK.

The best way for the city poultry keeper to procure hens is to purchase them in the fall. An effort should be made to obtain pullets rather than older hens, and the pullets selected should be well matured, so that they will begin to lay before the cold weather sets in. Evidences of the maturity of pullets are the development and red color of the comb and a size and growth which are good for the breed or variety. Hens will lay little or no eggs during the fall and early winter, while they are molting. Well-matured pullets, however, should lay fairly well during this period, so that an immediate return is realized from the investment. The purchasing of pullets in the fall is preferable in most cases to purchasing day-old

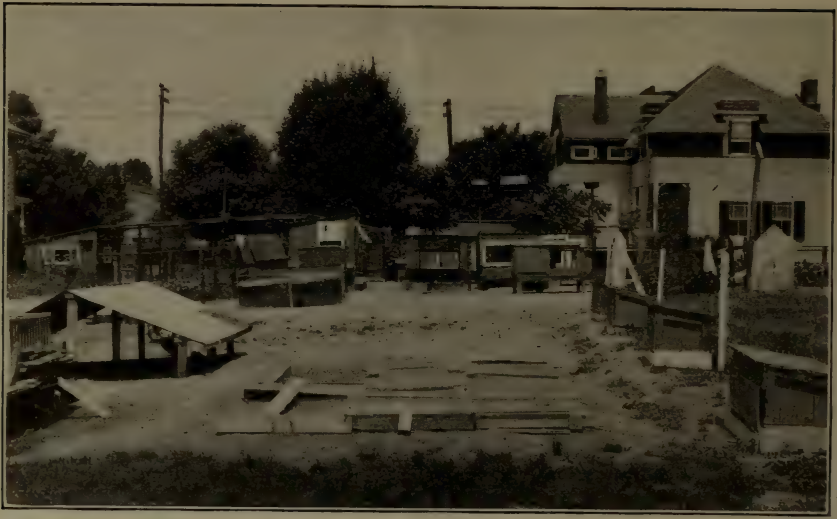

FIG. 2.—A back-yard poultry plant. In the background are the poultry houses set up off the ground on account of rats. At the left is a shade made of wooden strips and roofing paper. At the right are the coops for the hens and chicks. In the foreground oats for green feed are being sprouted under wire screens.

chicks or to hatching chicks in the spring. Usually there is little space available for the raising of chicks, and, moreover, many city dwellers have had no experience in raising them. Under these conditions the results are apt to be very poor. Hatching and rearing chicks also necessitates broody hens for this purpose, or else investing money in artificial apparatus such as incubators and brooders. Such an investment is often too great to prove profitable with the average small flock. If chicks are raised, they must be fed throughout the summer and no return will be obtained until the pullets begin to lay in the fall, except that the males can be eaten or sold.

When pullets are to be purchased, it is well if possible to go to some farmer or poultryman who may be known to the prospective purchaser. In some cases it may pay to make arrangements with the farmer to raise the desired number of pullets at an agreed price. Where the householder does not have an opportunity to go into the country for his pullets, he can often pick them out among the live poultry shipped into the city to be marketed. The advice of some one who knows poultry should be sought in making such a purchase, to make sure that pullets or young hens are obtained, and that the stock is healthy. Often the local poultry associations are glad to help the prospective poultry keeper to get stock by putting him in communication with some of its members having stock for sale. Sometimes the local board of trade or chamber of commerce is glad to help to bring together the prospective purchaser and the poultry raiser.

HOUSING.

The flock should be comfortably but not expensively housed. A house which provides a floor space of 3 or 4 square feet per bird is ample for the purpose, and fowls are often successfully kept with an allowance no greater than 2½ to 3 square feet. Houses must be dry and free from draft, but must allow ventilation. Often there is an unused shed or small building on the place which can easily be converted into a chicken house (see fig. 3). The front of the poultry house should be faced toward the south, if possible, so that the sun will shine into it. Perfectly satisfactory houses can be made cheaply from piano boxes or other packing cases. Two piano boxes with the backs removed can be nailed together and a door cut in the end. These boxes should be covered with a roofing paper in order to keep the house dry and to make it wind-proof. A portion of the door should be left open or covered with a piece of muslin, so as to allow ventilation. (See figs. 4 and 5.) Similar houses can be constructed of packing cases at a relatively small cost. A small amount of 2 by 4 or 2 by 3 lumber can be purchased for framing. The box boards can be applied for siding or sheathing and then covered with roofing paper. Where there is a board fence it is sometimes possible to take advantage of this by building the poultry house in the corner of the fence, and making the fence itself, with the cracks covered by strips or battened, serve as the back and one side of the house.

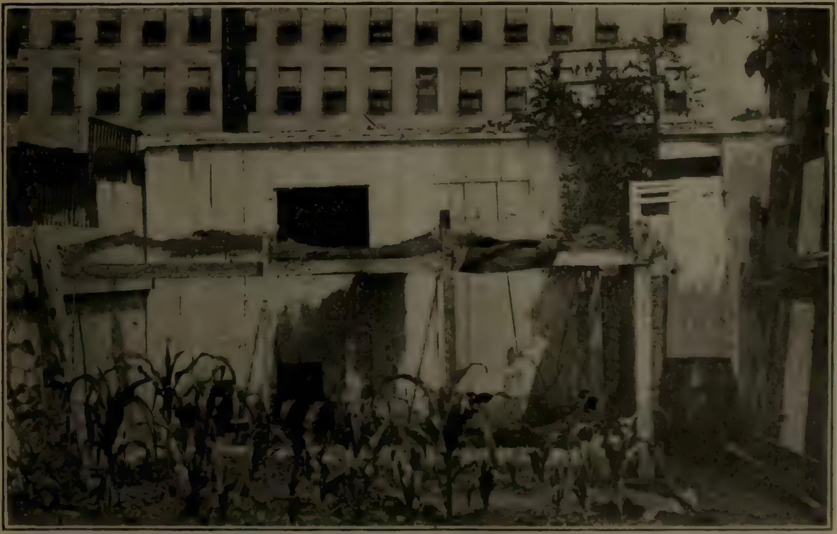

FIG. 3.—A shed in the heart of the city utilized for a poultry house. While a larger opening in the front would admit more light and make a more suitable hen house, the fowls kept here have done very well. The wire netting used for the yard was purchased very cheaply at an auction. The grass and sacks shown on the top of the run are used to furnish shade.

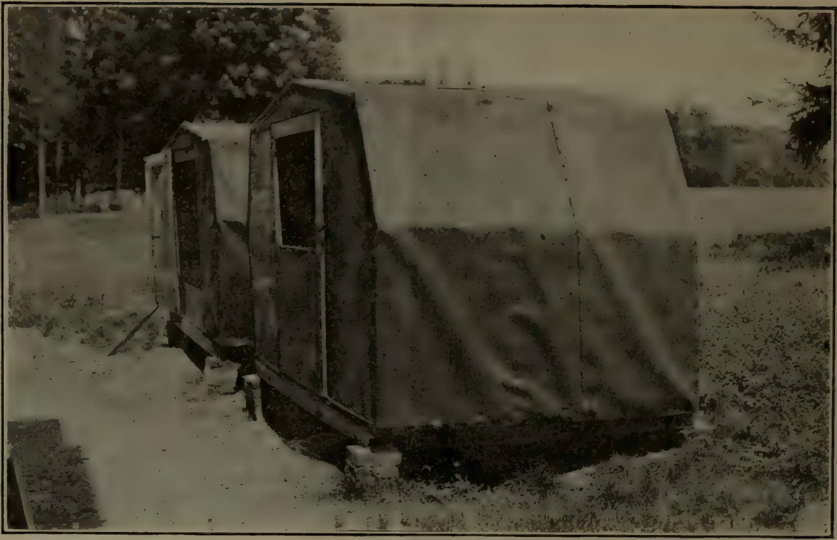

FIG. 4.—Poultry houses, each of which is made out of two piano boxes. The two boxes are placed back to back, 3 feet apart, the back and top of each removed, a frame for roof and floor added, and the part between the two boxes built in with the boards removed from the boxes. The whole is covered with roofing paper. With piano boxes at $2.50 each, such a house can be easily and quickly constructed for $12. It will accommodate 12 hens comfortably.

A cheap house 8 by 8 feet square can be made of 2 by 4 inch pieces and 12-inch boards. Plans for such a house are given in figure 6. The 2 by 4 pieces are used for sills, plates, corner posts, and three rafters. No studding is required except that necessary to frame the door and window space. The boards are run up and down and add sufficient stiffness to the house. They are used also for the roof and covered with roofing paper. The back and sides of the house also can be covered with roofing paper, or the cracks can be covered with wooden battens or strips 1½ to 3 inches wide. In the front of the house there should be left a window or opening which can be closed, when desired, by a muslin screen or curtain which serves as a protection against bad weather but allows ventilation. In the side a door should be provided which will allow entrance. A shed or single-slope roof is best because easiest to build. A height of 6 feet in front and 4 feet in the rear is ample. If desired, the house may be built higher, so that it is more convenient to work in; the increase in cost will be slight. The ventilator in the rear is not needed in the northern part of the country, but is desirable in the South where summers are very warm.

Such a house would be ample for a flock of 20 to 25 hens. It can be built quickly and easily and is cheap in construction. The material required is as follows:

BILL OF MATERIAL.

Roof rafters, 5 pieces, 2 by 4 inches by 8 feet long.
Roof plates, 2 pieces, 2 by 4 inches by 8 feet long.
Sills, 4 pieces, 2 by 4 inches by 8 feet long.
Posts, 3 pieces 2 by 4 inches by 6 feet long; 2 pieces 2 by 4 inches by 4 feet long.
Stringer, 1 piece, 2 by 4 inches by 8 feet long.
Total pieces required to cut list:
7 pieces 2 by 4 inches by 16 feet feet long.
1 piece 2 by 4 inches by 12 feet long.
Total feet in board measure, 81.

ROOSTS AND DROPPING BOARD.

1 piece 2 by 3 inches by 16 feet long.
1 piece 2 by 3 inches by 10 feet long.
Total board measure, 13 feet.
2 pieces 1 by 12 inches by 16 feet long.
Total board measure, 32 feet.

SHEATHING BOARDS.

Roof, 5 pieces 1 by 12 inches by 16 feet long.
Two sides, 2 pieces 1 by 12 inches by 10 feet long; 3 pieces 1 by 12 inches by 12 feet long; 2 pieces 1 by 12 inches by 14 feet long.
Front, 2 pieces 1 by 12 inches by 10 feet long.
Back, 2 pieces 1 by 12 inches by 16 feet long.
Total feet board measure, 216.

BATTEN STRIPS.

130 linear feet ½ by 2 inch strips, 24 board feet.
24 linear feet ⅞ by 2 inch strips, for curtain frame, 4 board feet.

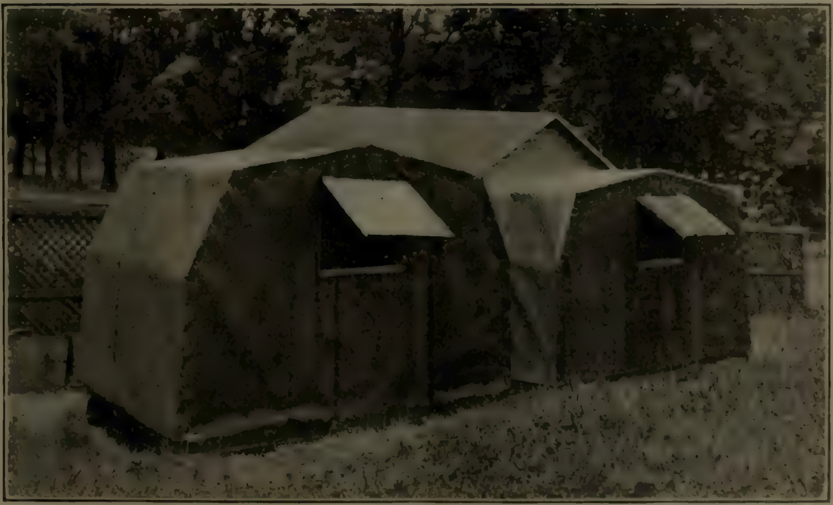

FIG. 5.—Rear view of piano-box houses shown in fig. 4. The openings at the rear are provided for ventilation and coolness in the hot weather. Windows could be used instead of solid shutters and would make the houses lighter when closed.

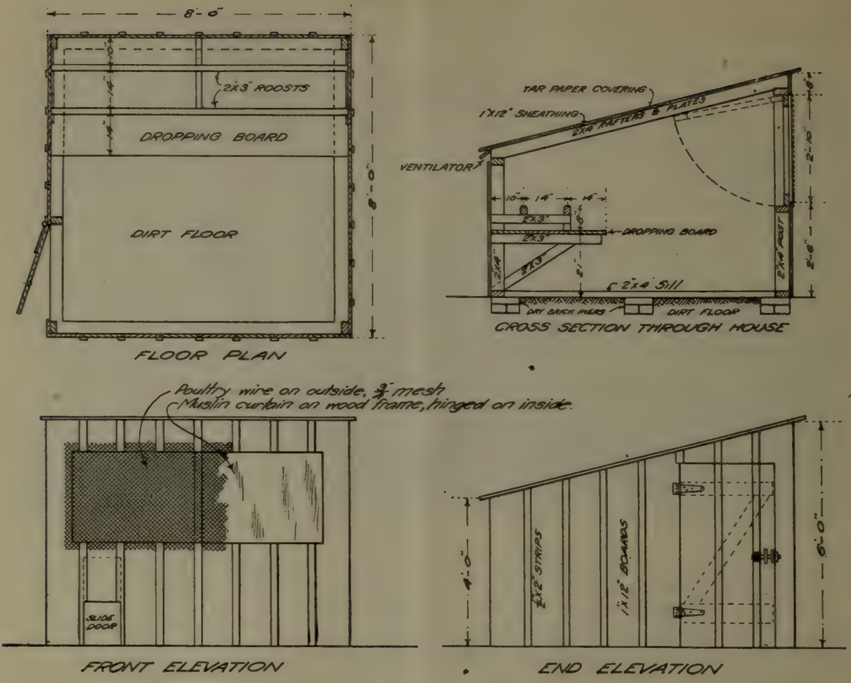

FIG. 6.—Plan of a simple back-yard poultry house.

ROOFING.

80 square feet roofing paper; nails and tins.

HARDWARE.

2 pairs 8-inch T hinges for door.
1 padlock for door.
3 pairs 4-inch T hinges for curtain frame and rear ventilator.
5 pounds 10-penny wire nails for framing.
10 pounds 8-penny wire nails for sheathing.
5 pounds 4-penny wire nails for stripping.
21 square feet poultry wire, ¾-inch mesh, for front.
3 yards muslin for curtain.
32 rough bricks will build piers.

FLOOR.

If floor is desired in house, add the following material:
2 pieces 2 by 4 inches by 16 feet long.
4 pieces 1 by 12 inches by 16 feet long.
Total feet board measure, 85.

TOTAL LUMBER REQUIRED.

Without floor, 370 board feet.
With floor, 455 board feet.
Lumber can be rough or dressed.

When the soil is well drained and consequently will remain dry no floor need be used in the house, the ground itself serving as the floor. Often a slight dampness can be corrected by filling up the floor several inches above the outside ground with sand, cinders, gravel, or dry dirt. Three or four inches of the surface of the floor, and of the run if a very small run is used, should be removed and replaced with fresh dirt two or three times a year. If the ground is so wet or damp that this condition can not be corrected by filling it is best to provide a board floor, as this will help to keep the house dry, will allow easier cleaning, and will promote the general health and welfare of the hens. A house with a board floor should be set on posts or blocks, so that it is 5 to 12 inches above the ground. When this space is left the floor will not rot so quickly and rats are not so likely to take refuge under the house. (See fig. 7.)

In order to keep the flock in a clean and sanitary condition, dropping boards should be provided and roosts above them. This makes it easy to remove the droppings each morning and helps greatly to keep the house free from objectionable odors. A little sand or ashes sprinkled on the dropping board after each cleaning will be found to make the cleaning easier.

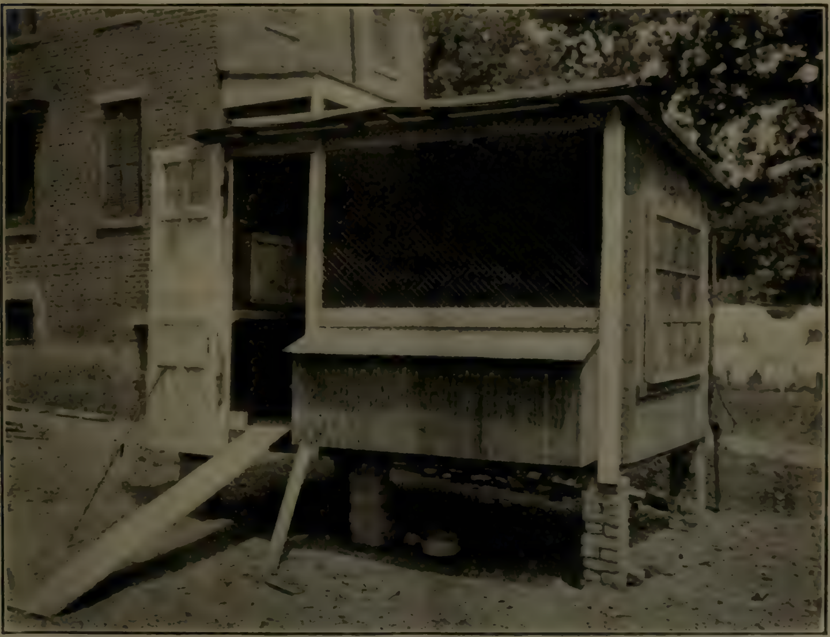

FIG. 7.—A good type of open-front poultry house for a small flock. The front can be closed with a muslin curtain on cold nights. The house is set on brick piers so as not to afford a refuge for rats. Notice the nests built out on the front of the house where the eggs can be reached by raising the hinged cover.

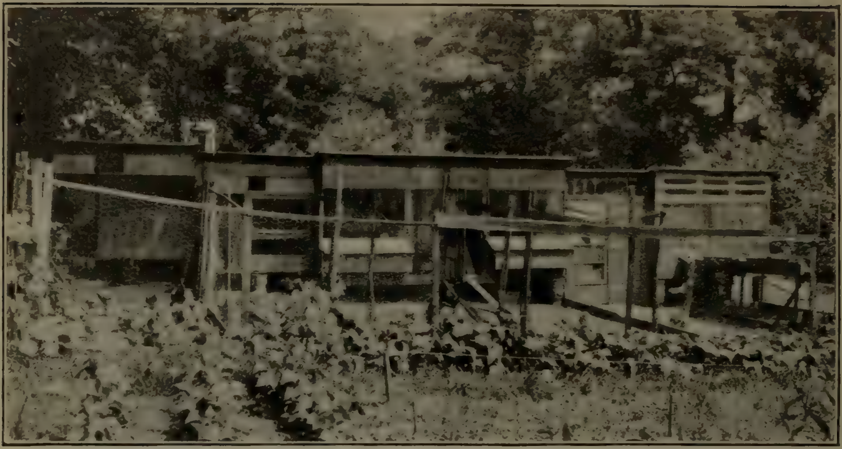

FIG. 8.—A larger poultry house suitable for a suburban lot. Notice the old lumber, sash, etc., used in the construction. The utilization of such used material, which can often be purchased for a very slight sum at auction or where buildings are being wrecked, lessens the cost of the poultry buildings very materially.

The dropping boards and roosts should be placed against the back wall. Here they are out of the way and at the same time where they are least likely to be reached by drafts. The dropping boards should be about 20 to 30 inches from the floor, depending on the height of the building. This gives space enough under them so that the hens have room to exercise and is not too high for the heavier hens to fly up to. The roosts should be 3 or 4 inches above the drooping boards. If more than a single roost is used, they should be on the same level; otherwise all the hens will try to crowd upon the highest roost. A piece of 2 by 4 or 2 by 3, laid on edge and with the upper corners rounded off, makes a good roost. A pole, or even a piece of board 2 or 3 inches wide, may be used. If the roost is of light material and fairly long, it should be supported in the center, as well as at the ends, to prevent it from sagging badly. An allowance of 7 to 10 inches of roost space per fowl, according to the size of the birds, should be made. If more than one roost is used, they should be placed about 15 inches apart.

Nests must be provided and may be very simple. Any box about 1 foot square and 5 or 6 inches deep is suitable. An ordinary orange box with the partition in the middle serves this purpose very well, each box forming two nests. The top is removed, the box laid on its side, and a strip 3 to 4 inches wide nailed across the lower front. (See fig. 9.) Nests can be fastened against the walls of the house or set on the floor. It is preferable to fasten them against the wall, as they take too much floor space if set on the floor. One nest should be provided for each 4 or 5 hens.

The straw or other material used in the nest should be kept clean and not be allowed to get so low that the eggs when laid by the hen will strike the board bottom of the nest, as this will cause them to break and will start the hens to eating the eggs, which is a very troublesome habit and one that is very difficult to break up once it is formed.

A litter of straw or the leaves raked up in the fall about 3 or 4 inches deep, should be used on the floor of the house. This material helps to absorb the droppings and also provides a means of feeding the grain in such a way that the hens are obliged to exercise by scratching for it.

When hens become broody, they should be "broken up" as quickly as possible, for the sooner this is done the sooner they will resume laying. To break a hen of broodiness she should be confined to a small coop, preferably with a slat bottom. Give her plenty of water to drink; she may be fed or not as desired. Not much difference will be found in the time required to break her of broodiness, whether she is fed or made to fast. Usually from 3 to 6 days' confinement will break her, but some hens require 10 to 12 days. The broody hen will be recognized by her inclination to stay on the nest at night, the ruffling of her feathers and her picking at anyone who approaches her, and by the clucking noise she makes. The fact that her broodiness has been broken up can be recognized by the disappearance of these symptoms.

THE YARD.

The yard should be inclosed by a board or wire fence. Wire fencing is preferable, as it is cheaper and the hens are less likely to fly over it. If cats prove troublesome, where one is raising young chickens, it may be necessary to cover the top of the yard with wire also. A board should not be used at the top of a wire fence, as this gives the hens a visible place to alight and tends to teach them to fly over. A 5-foot fence is high enough for most conditions, but if the hens show a tendency to fly over such a fence the flight feathers of one wing should

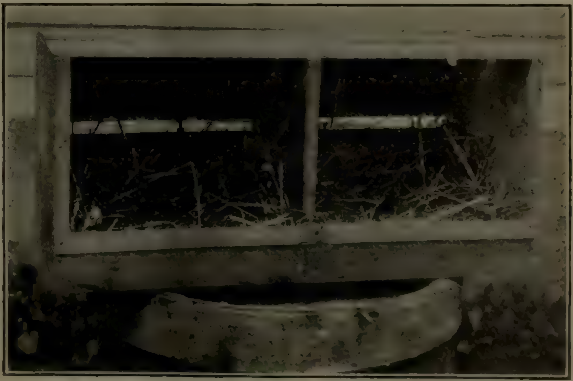

FIG. 9.—An orange box converted into a double nest by laying it on its side and nailing strips across the front to hold in the nesting material.

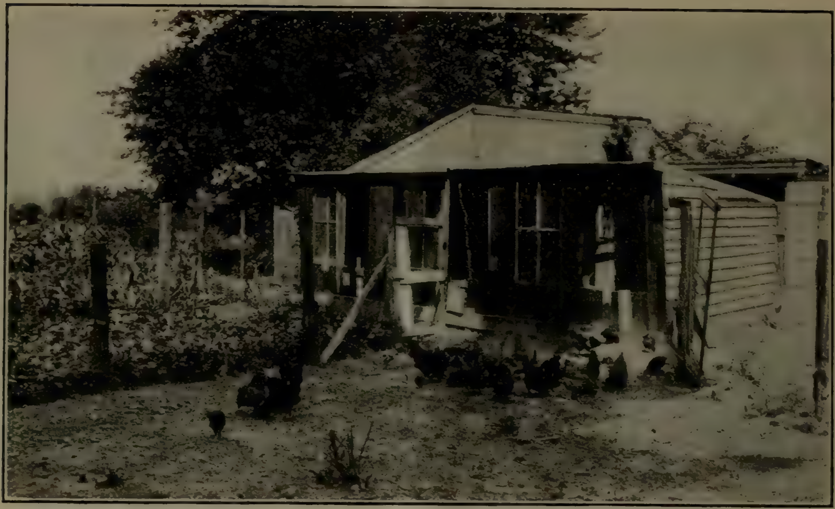

FIG. 10.—Back-yard poultry house and flock. Notice the double yard. The green crop of the first yard has been fed off and the second yard is planted to rape, which is about ready to feed. The mulberry tree in the background provides, when the berries are ripe, nearly enough feed for a flock of 25 hens for three weeks.

be clipped. The larger the yard which can be provided the better the hens will do, as it not only gives them greater opportunity to exercise, but also makes it possible to maintain a sod on the yard. In most cases not enough land will be available so that a sod can be maintained.

If the yard is fairly large, it can be divided into two parts and green crops, such as oats, wheat, rye, or dwarf essex rape, allowed to start in one yard while the hens are confined to the other. (See fig. 10.) The green crops should be sown very thick, and the following quantities will be found satisfactory for a yard 25 by 30 feet: Wheat, 2¾ pounds; oats, 1½ pounds; rye, 3¼ pounds; rape, 5 ounces. When the growing stuff reaches a height of 2 or 3 inches the hens can be turned upon it and the other yard be similarly sown.

Where it is inadvisable to divide the yard, it is possible to keep a supply of green stuff growing by using a wooden frame 2 or 3 inches high, covered with 1-inch-mesh wire. A frame made of 2 by 4 lumber, 6 feet long and 3 feet wide, with an additional piece across the center to support the wire when the hens stand on it, will be found desirable for a small yard. (See fig. 11.) A part of the yard as large as this frame is spaded up and sown, the frame placed over it, and the material allowed to grow. As soon as the green sprouts reach the wire the hens will begin to pick them off, but since they can not eat them down to the roots the sprouts will continue to grow and supply green material. This frame can be moved from place to place in the yard, and in this way different parts cultivated.

The yard should be stirred or spaded up frequently if not in sod in order to keep it in the best condition. This will not only tend to keep down any odors which might arise, but also allow the droppings to be absorbed into the soil more readily and therefore keep the yard in better condition for the hens.

Although it is necessary to keep the hens confined to their yard most of the time, it is sometimes possible to let them out where they may range upon the lawn for an hour or so in the evening when some one can be at hand to watch them, or at certain seasons of the year to allow them to run in the garden plot. This will be enjoyed greatly by the hens and will be very beneficial to them.

FEEDING.

In feeding the city flock an effort should be made to do so as cheaply as possible, consistent with the production of eggs. To accomplish this, all table scraps, kitchen waste, etc., should be utilized. Scraps of meat or left-over vegetables which can not be utilized in any other way make excellent feed. There are also many other waste products, such as beet tops, turnip tops, carrot tops, potato parings, onion tops, watermelon and cantaloup rinds, the outside leaves of cabbages, waste lettuce leaves, bread and cake crumbs, etc., all of which are relished by the hens and can be used to the best advantage. In saving the scraps and waste it is well to separate the portions adapted for feeding to the flock and place these in a receptacle or pail of their own. Decomposed waste material or moldy bread or cake should never be saved to feed to the hens, as it is harmful to them and may cause serious bowel trouble. Sloppy material, such as dishwater, should not be thrown into their pail. It is also useless to put in such things as banana peels or the skins of oranges, as these have little or no food value. Any sour milk which is not utilized in the house

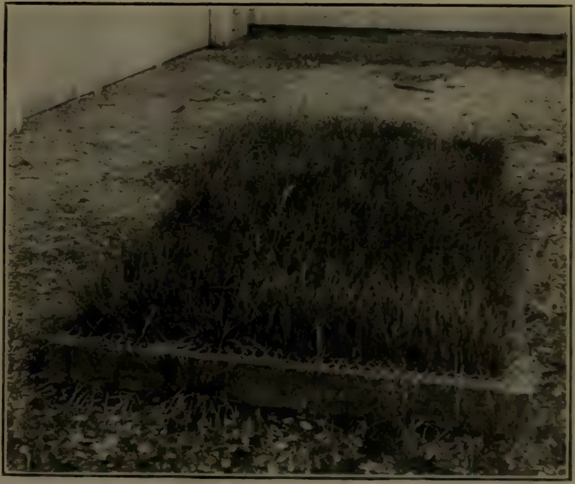

FIG. 11.—A frame made of 2 by 4 inch lumber and covered with ¾-inch mesh poultry wire used to sprout oats or other grain for the hens. The wire prevents the hens from eating the sprouts down so close as to kill the plants and from scratching out the roots. Sprouting grain unprotected will be quickly killed.

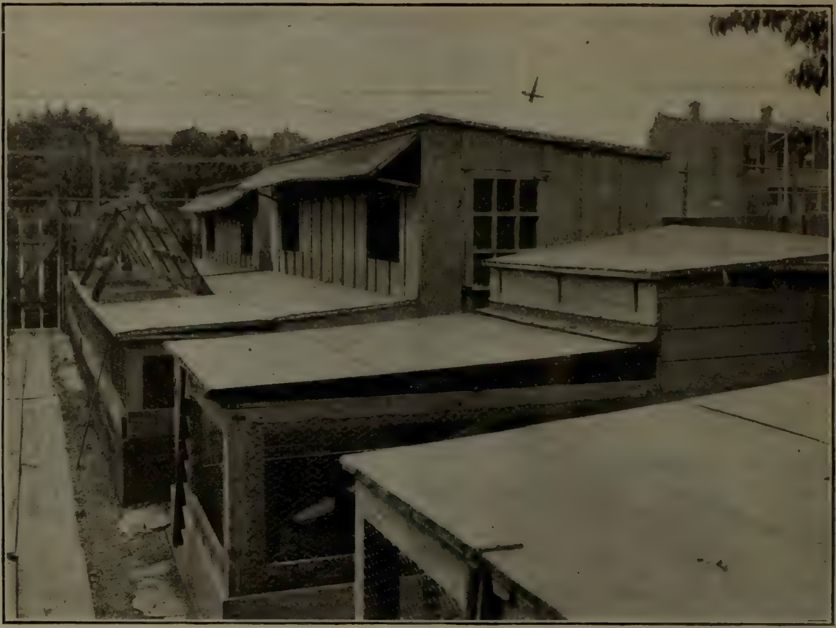

FIG. 12.—An intensive back-yard poultry plant. Practically the entire back yard is occupied by houses and covered runs, and about 70 hens are carried. Each house is 6 by 14 feet, divided into two pens with a covered yard of the same size. Each pen carries about 15 hens. The houses are raised from the ground so that the hens can run under them. The soil in the runs is renewed four times a year. A flock of 13 hens in one of these pens laid 2,163 eggs in a year. Oats are sprouted in the cellar of the dwelling house for green feed. In addition, chickens are raised here.

should be given to the chickens. This should be fed separately, however, either by allowing the hens to drink it or by allowing it to clabber on the back of the stove and then feeding it in that condition. When the family's table waste is not sufficient for feeding the flock, it is usually possible to get some of the neighbors who keep no hens to save material suitable for feeding. Many people are glad to do this if a small pail in which to place the waste is furnished.

Table scraps and kitchen waste are best prepared for feeding by running them through an ordinary meat grinder. After the material has been put through the grinder it is usually a rather moist mass, and it is well to mix with it some corn meal, bran, or other ground grain until the whole mass assumes a crumbly condition. The usual method is to feed the table scraps at noon or at night, or at both times, as may be desired, in a trough or on a board. All should be fed that the hens will eat up clean, and if any of the material is left after one-half or three-quarters of an hour it should be removed. If allowed to lie it may spoil and would be very bad for the hens.

With the table scraps it is well to feed some grain. Perhaps this may be given best as a light feed in the morning. Four or five handfuls of grain (about ½ pint) scattered in the litter will be sufficient for a flock of 20 or 25 hens. By handful is meant as much as can be grasped in the hand, not what can be scooped up in the open hand. By scattering it in the litter the hens will be compelled to scratch in order to find the grain and in this way to take exercise, which is decidedly beneficial to them. If the house is too small to feed in, the grain can be scattered on the ground outside. A good grain mixture for this purpose is composed of equal parts by weight of wheat, cracked corn, and oats. Another suitable grain mixture is composed of 2 parts by weight of cracked corn and 1 part oats.

In addition to the grain and the table scraps it is well to feed a dry mash. This dry mash is composed of various ground grains and is placed in a mash hopper or box from which the hens can help themselves. The advantage of feeding such a mash is that the hens always have access to feed, and this tends to make up for any faulty, inexperienced, or insufficient feeding. The hens do not like the dry mash so well that they are likely to overeat, but it will supply a source of feed in case they are not getting enough. The dry mash also provides a suitable medium for feeding beef scrap, a certain amount of which may or may not be necessary, depending upon the amount of meat scraps available in the table waste. If the hens show a tendency to become overfat it may be desirable to close the mash hopper during a part of the day and allow them access to it only during a certain period, preferably the afternoon. A good dry mash is composed of equal parts by weight of corn meal, wheat bran, wheat middlings, and beef scrap. Another good mash is composed of 3 parts by weight of corn meal and 1 part beef scrap. Still a third mash, which

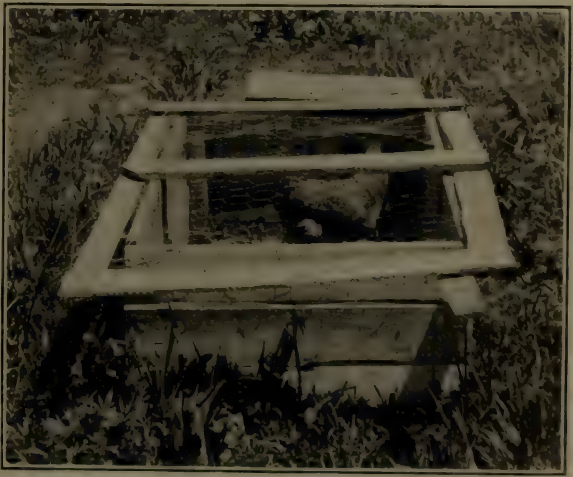

FIG. 13.—Inclosure for hen and chicks with box used as a coop at the end. Both coop and run is moved each day to a fresh spot of ground. A burlap bag thrown across the top of the yard provides shade. Twenty-five chicks were put with a hen in this yard and 24 of them were raised, making good growth.

has given excellent results, is composed of 1 pound of wheat bran, 1 pound of wheat middlings, 6.5 pounds of beef scrap, and 16.5 pounds of corn meal. The beef scrap used in the dry mash is usually the most expensive ingredient, but it is a very essential part of the mash and very efficient for egg production. It should not be eliminated or reduced unless the quantity of meat in the table scraps is considerable or unless some other product can be substituted for it. Fish scrap, when available, may replace the beef scrap, or cottonseed meal can be used to replace one-half the beef scrap in the mash. No attempt should be made to replace more than half the beef scrap with cottonseed meal, as the results in egg production and in the quality of the eggs will be unsatisfactory.

Green cut bone can often be purchased from the butcher. This material when procured fresh makes an excellent substitute for beef scrap. It should be purchased in small quantities, as it can not be kept fresh for any length of time and when spoiled may cause severe bowel trouble. It is best fed in a trough not oftener than every other day, allowing about one-half ounce per bird. Should severe or continued looseness of the bowels follow the feeding of green cut bone it should be discontinued or the quantity reduced.

Vegetable tops, parings, and other vegetable refuse supply a valuable and very necessary green feed for the hens. Lawn clippings also are a valuable green feed. They can be fed as soon as cut, or they may be dried or cured, stored in bags, and saved until winter, when they can be soaked in warm water and fed in that condition or be mixed with some of the mash or with the table scraps.

The hens should have access at all times to a supply of grit or stones of a size small enough to be swallowed readily. Grit is used by the hens to help in grinding in their gizzards the hard grains which they eat. A supply of ordinary gravel will answer the purpose of grit very well. Crushed oyster or clam shell also should be given to the hens and be kept before them at all times. If this is withheld the hens are likely to lack sufficient shell-forming material in their feed, with the result that they lay many soft-shelled or thin-shelled eggs. Grit or shell can be purchased in small quantities at any feed or poultry supply store.

A plentiful supply of clean, fresh water must always be available to the hens. The fowls drink freely, especially when laying heavily, and should not be stinted of such a necessary and cheap material as water. The water pan or dish should be kept clean. If it is not washed out frequently a green slime will gather on its inner surface. This should not be allowed to happen. It is well to keep the water pan outside the house and in the shade in the summer, but in the winter, when the water may freeze, it is best that the pan be left in the house, and it should be raised about a foot above the floor so that the hens will not kick it full of straw or other litter when scratching for their feed. When the nights are cold enough so that the water is likely to freeze the pan should be emptied each night and refilled in the morning.

LICE AND MITES.[1]

If the best results are to be expected from the flock, the hens must not be allowed to become overrun with lice or the house with mites. Usually there will be a place in the yard where the hens can dust themselves in the dry dirt. If such a place is not available, a box large enough (about 2 feet square) for the hens to get into it should be provided in the house and a quantity of dust such as ordinary road dust or fine dirt placed in it to allow the hens a place to dust themselves. A dust bath aids the hens in keeping lice in check and therefore adds to their comfort. Usually the lice are not present on the birds in sufficient number to prove particularly harmful. However, it is better to keep the hens as free as possible from this pest, and if they are not able to keep them in check by dusting themselves, other measures can be undertaken.

To rid the hens of lice, each one can be treated by placing small pinches of sodium fluorid, a material which can be obtained at most large drug stores, among the feathers next to the skin—one pinch on the head, one on the neck, two on the back, one on the breast, one below the vent, one at the base of the tail, one on either thigh, and one scattered on the underside of each wing when spread. Another method is to use a small quantity of blue ointment, a piece about as large as a pea on the skin 1 inch below the vent. If mercurial ointment is used instead of blue ointment, it should be diluted with an equal quantity of vaseline. Any of these methods will be found very effective in ridding the hens of lice and should be employed whenever the lice become troublesome. Two or three applications a year usually prove sufficient.

Mites are more troublesome and more harmful than lice. They do not live upon the birds like the lice, but during the day hide in the cracks and crevices of the roosts and walls of the house, and at night they come out and get upon the fowls. They suck the hen's blood, and if allowed to become plentiful—as they certainly will if not destroyed—will seriously affect her health and consequently her ability to lay eggs. They may he eradicated by a few thorough applications of kerosene or some of the coal-tar products which are sold for this purpose, or crude petroleum, to the interior of the poultry house. The commercial coal-tar products are more expensive but retain their killing power longer, and they may be cheapened by reducing with an equal part of kerosene. Crude petroleum will spray better if thinned with 1 part of kerosene to 4 parts of the crude oil. Both the crude petroleum and the coal-tar products often contain foreign particles, so should be strained before attempting to spray. One must be sure that the spray reaches all of the cracks and crevices, giving especial attention to the roosts, dropping-boards, and nests, and the treatment should be repeated two or three times at intervals of a week or 10 days.

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[1] For further information on the subject of poultry lice and mites and their control the reader is referred to Farmers' Bulletin 801, "Mites and Lice on Poultry," by F. C. Bishopp and H. P. Wood, of the Bureau of Entomology. Copies of this bulletin may be obtained free on application to the Division of Publications, United States Department of Agriculture.

HATCHING AND RAISING CHICKS.

Often it is inadvisable to attempt to renew the city poultry flock by hatching and rearing chicks or buying and rearing day-old chicks. Previous experience in the raising of chickens often increases the chances of success. However, the land available is usually small in area, and no attempt should be made to raise chicks unless a plot can be provided separate from that to which the hens have access and upon which there is grass, or a supply of green feed can be furnished. Where these conditions are not available, it is better to kill the hens as soon as they have outlived their usefulness and replace them by well-matured pullets in the fall. Where it is found desirable to hatch and rear a few chicks this can best be done with hens. Where a few day-old chicks are purchased to rear and no hens are available for the purpose, it is possible with little trouble and expense to construct a fireless brooder which will answer the purpose. Full directions for making such a brooder are given in Farmers' Bulletin 624, page 10.[1]

The hatching should be done early in the spring and should be completed if possible by the first of May. Chicks hatched before this time will have a good chance to mature and be in laying condition as pullets before the cold weather of fall sets in, and should in consequence be producers during the entire fall and winter. Early-hatched chicks are also easier to raise, as they live and thrive better than those which are still small when the hot weather begins. If it is desired to hatch and raise chicks, the reader is referred to Farmers' Bulletin 585, "Natural and Artificial Incubation of Hens' Eggs," and 624, "Natural and Artificial Brooding of Chickens."[1]

CULLING THE HENS.

In any flock some hens will be found to be much better producers than others. Often there are a few hens which are such poor producers that they are unprofitable. Where the flock is comparatively small, the owner is often able to determine by observation which are the poor producing hens. Needless to say, these should be the ones to kill and eat as fowls are desired for the table. All hens molt in the fall and early winter. During this molting season, which usually takes about three months, the hens lay few or no eggs. It is advisable, if well-matured pullets can be purchased at a reasonable price, to kill and eat the hens as they begin to molt, replacing the flock with newly purchased pullets. The hens should not be killed, however, until they begin to molt and their comb begins to lose its size, color, and flexibility, for if these changes have not taken place the hens will probably still be laying and at a time of year when eggs are especially valuable.

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[1] Copies of these publications may be obtained free from the Division of Publications, U. S. Department of Agriculture.

PRESERVING EGGS.

A small flock of hens, even five or six, may produce enough eggs during the greater part of the year to supply the needs of a medium-sized family. Where a larger flock is kept, there will be a time during the spring and early summer when more eggs are produced than are used. These surplus eggs can either be sold or, what is perhaps more desirable, preserved in the spring for home use during the fall and early winter, when eggs are high in price and much more difficult to obtain from the flock.

The eggs to be preserved must be fresh. They should be put in the preserver on the day on which they are laid. The eggs should be clean, but it is better not to wash them. Eggs with dirty shells can be used for immediate consumption and the clean eggs preserved. Cracked eggs or those with thin or weak shells should never be used for preservation. Not only will the cracked egg itself spoil, but it will cause many of the other eggs packed in the same jar with it to spoil as well.

One of the best methods of preserving eggs is by the use of waterglass. This material can be purchased by the quart from the druggist or poultry supply men. It is a pale yellow, odorless, sirupy liquid. It should be diluted in the proportion of 1 part of waterglass to 9 parts of water which has been boiled and allowed to cool. Earthenware crocks or jars are the best containers for the purpose, since they have a glazed surface and are not subject to chemical action from the solution. The crocks or cans should be scalded out, so that they will be perfectly clean, and allowed to cool before they are used. A container holding 6 gallons will accommodate 18 dozen eggs and will require about 22 pints of solution. Too large containers are not desirable, since they increase the liability of breaking some of the eggs. Half fill the container with the waterglass solution and place the eggs in it. Eggs can be added from day to day as they are obtained, until the container is filled. Be sure that the eggs are covered with about 2 inches of waterglass solution. Cover the container and place it in a cool place, where it will not have to be moved.

It should be looked at from time to time to see that not enough of the water has evaporated so that the eggs are uncovered. If there seems to be any danger of this, sufficient cool boiled water should be added to keep them covered.

Remove the eggs from the solution as desired for use and rinse them in clean, cold water. Before boiling such eggs prick a tiny hole in the large end of the shell with a needle, to keep them from cracking. As the eggs age the white becomes thinner and is harder to beat. The yolk membrane becomes more delicate, and it is correspondingly difficult to separate the whites from the yolks.

Limewater is also satisfactory for preserving eggs and is slightly less expensive than waterglass. A solution is made by placing 2 or 3 pounds of unslaked lime in 5 gallons of water which has been boiled and allowed to cool, and allowing the mixture to stand until the lime settles and the liquid is clear. The eggs should be placed in a clean earthenware jar or other suitable vessel and covered to a depth of 2 inches with the liquid. Remove the eggs as desired, rinse in clean, cold water, and use immediately.

PRACTICAL POINTERS.

Keep the hens confined to your own land.

Don't keep a male bird. Hens lay just as well without a male.

Don't overstock your land.

Purchase well-matured pullets rather than hens.

Don't expect great success in hatching and raising chicks unless you have had some experience and have a grass plot separate from the yard for the hens.

Build a cheap house or shelter.

Make the house dry and free from drafts, but allow for ventilation.

Fowls stand cold better than dampness.

Keep house and yard clean.

Provide roosts and dropping boards.

Provide a nest for each four or five hens.

Grow some green crop in the yard.

Spade up the yard frequently.

Feed table scraps and kitchen waste.

Also feed grain once a day.

Feed a dry mash.

Keep hens free from lice and the house free from mites.

Kill and eat the hens in the fall as they begin to molt and cease to lay.

Preserve the surplus eggs produced during the spring and summer for use during the fall and winter when eggs are scarce and high in price.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO THE CARE OF POULTRY.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Standard Varieties of Chickens. (Farmers' Bulletin 51.)
Poultry Management. (Farmers' Bulletin 287.)
Successful Dairy and Poultry Farm. (Farmers' Bulletin 355.)
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Hints to Poultry Raisers. (Farmers' Bulletin 528.)
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Poultry House Construction. (Farmers' Bulletin 574.)
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Duck Raising. (Farmers' Bulletin 697.)
Goose Raising. (Farmers' Bulletin 767.)
Mites and Lice on Poultry. (Farmers' Bulletin 801.)
Standard Varieties of Chickens: 1. The American Class. (Farmers' Bulletin 806.)
How the Produce Dealer May Improve Quality of Poultry and Eggs. (Separate 596 from Year Book 1912.)
Thanksgiving Turkey. (Separate 700 from Year Book 1916.)
Back Yard Poultry Leaflet. (Secretary's Miscellaneous.)
The Chicken Mite, Its Life History and Habits. (Department Bulletin 553.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Refrigeration of Dressed Poultry in Transit. (Department Bulletin 17.) Price, 10¢.
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Lessons on Poultry for Rural Schools. (Department Bulletin 464.) Price, 10¢.
Food Value and Uses of Poultry. (Department Bulletin 467.) Price, 5¢.
Eggs and Their Value as Food. (Department Bulletin 471.) Price, 5¢.
Improvement of Farm Eggs. (Bureau of Animal Industry Bulletin 141.) Price, 10¢.
Capons and Caponizing. (Bureau of Animal Industry Circular 107.) Price, 5¢.

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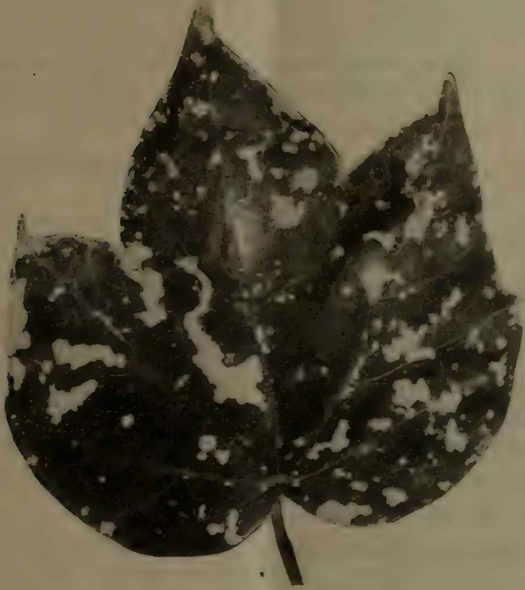
HOW INSECTS AFFECT THE COTTON PLANT AND MEANS OF COMBATING THEM

W. DWIGHT PIERCE
Entomologist, Southern Field Crop Insect Investigations



FARMERS' BULLETIN 890

UNITED STATES DEPARTMENT OF AGRICULTURE

[illegible]

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C.
December, 1917

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THE COTTON PLANT is unusually attractive to insects and probably no other cultivated crop has as large a list of insect enemies. Among these are some of the most destructive pests in the history of agriculture.

Many cotton pests come to the cotton from other crops or from weeds around the fields. Weeds should not be allowed to grow.

Rotation of crops is of assistance in controlling cotton pests.

An early crop is necessary.

Poisons seldom are needed, except in poisoned baits in the spring and against red spiders, grasshoppers, and "worms" when they threaten the crop.

Thorough fall plowing, winter cover crops, early spring preparation, and repeated cultivation during the season are important measures of insect control.

The cotton plants should be turned under in the fall.

This bulletin describes the work of many insects and gives suggestions for their control.

A single system of control, effective against most of the insects referred to, is given in summary form on pages 26 and 27.

HOW INSECTS AFFECT THE COTTON PLANT AND MEANS OF COMBATING THEM.

CONTENTS.

	Page.		Page.
How cotton attracts insects	3	How insects reduce the yield	16
How insects may be controlled before planting	4	Injuries to the stalk and roots	22
Pests that menace the stand of seedling cotton	4	Insects in decayed and dry bolls	24
Injuries which abort the growth	7	The double rôle of ants	24
Injuries to the growing tip	9	The parasites	25
Leaf injuries and defoliation	10	Insect visitors of cotton	26
		Summary of control measures	26

HOW COTTON ATTRACTS INSECTS.

NOT ONLY the squares and bolls of cotton, but the leaves and flowers are attacked by insects, and many species attack the stems and roots. In addition to the attraction of the plant to those insects which require it as food, the cotton plant is supplied with a peculiar means of attracting insects. On the underside of cotton leaves, on the midrib, or principal vein, and sometimes also on two other veins, one can find a little elongate depression which usually looks sticky and often holds a drop of liquid. On the outside of the squares at the base of each bract or leaflet are other little cups and between the bract and the bud itself are three more cups. At the bottom of the flower cup still others of these little vessels are found. They are called nectar cups, or nectaries, because they exude a sweet liquid. This liquid is greatly desired by many insects, beneficial and harmful, and is the means of attracting to the cotton plant a great variety of insect life.

As a result of the peculiar attractiveness of cotton for insects many specimens of harmless insects collected at the nectar are sent to entomologists under the impression that they are dangerous pests.

It would be impossible in a publication of this series to mention even briefly all of the cotton pests. The main object is to explain how insects affect the plant and to show how to distinguish the principal ones and how to combat them. The more important species, like the boll weevil and the bollworm, are treated fully in other publications.[1]

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[1] See Farmers' Bulletin 848, "The Boll Weevil Problem with Special Reference to Means of Reducing Damage," and Farmers' Bulletin 872, "The Bollworm or Corn Earworm." These may be obtained free from the Division of Publications, U. S. Department of Agriculture.

Insect attack against cotton begins with the seedling and continues until the plant is destroyed when picking is over. It seems best, therefore, to discuss the pests from the standpoint of the season and the manner of attack.

HOW INSECTS MAY BE CONTROLLED BEFORE PLANTING.

The control of many insect pests should begin in the spring before they begin their attack. While they are still in the shelter of woods, buildings, weeds, etc., or dormant in the ground they are most vulnerable.

WEED DESTRUCTION.

Thorough destruction of weeds and cleaning up fence rows and brush will invariably assist in the reduction of insect damage. Such insects as tree crickets and some of the leafhoppers lay their eggs in weed stems. Destruction of the weeds naturally will destroy them. Weed destruction should not stop with the first cutting but should continue through the season. Further emphasis will be placed on this in another section of the bulletin.

WINTER PLOWING.

During the winter the soil is likely to conceal many potential enemies of the crops about to be planted. It is the habit of many species of insects to pass the winter months as larva ("worm" stage) or pupa (resting stage) in cells in the ground, where they are protected from the weather. A winter or very early spring plowing which disturbs them and exposes them to cold and rain is far more effective than any measure taken after they emerge and begin to reproduce. Winter plowing is an aid in the control of the bollworm, cutworms, grasshoppers, May beetles, and many other insects which injure cotton.

PESTS THAT MENACE THE STAND OF SEEDLING COTTON.

Many factors in cotton production have combined to make it necessary that the farmer push the growth of his cotton plantings as rapidly as possible. This is especially important in order that the greater part of the crop may be made before insect injury can reach its maximum. Of course this means that the planter must plant as early as it can be done with reasonable expectation of escaping a killing frost. Every farmer who has lived a number of years in a locality knows the usual time that the last frosts occur on his place and also knows which parts of a plantation are to be planted early and which later. He understands that some of his land is cold and slow to develop plant growth and that some of it is warmer and permits a more rapid growth. In case of doubt the planter should ask advice from his State experiment station or the county demonstration agent.

In view of the necessity for an early crop, it is obvious that anything which retards the growth of the seedling cotton, or injures the stand so as to necessitate a replanting, is a serious drawback.

CUTWORMS.

The stand of cotton frequently is injured very seriously by cutworms (figs. 1, 2), of which there are numerous species. These "worms" are from one-half to an inch in length and of a dirty color. They hide in the ground in the daytime and come out at night to do their work, which consists in cutting the stem in two or feeding on the leaves. The same kind of work is sometimes done early in the season by the nearly related southern grass worm,[1] but this species rarely attacks the plant until later.

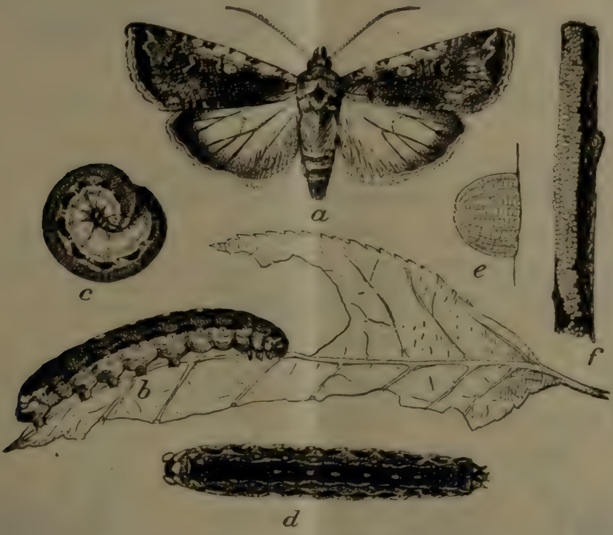

Fig. 1.—Varigated cutworm (*Peridroma margaritosa*): *a*, Moth; *b*, normal form of caterpiller, side view; *c*, same in curved position; *d*, dark form, view of back; *e*, greatly enlarged egg, seen from side; *f*, egg mass on twig. (Howard.)

The use of a poisoned bait is advisable if cutworms are numerous. This may be prepared as follows: Mix 50 pounds of wheat bran and 2 pounds of Paris green. Then bring the whole mixture to the consistency of a stiff dough by the addition of a low-grade molasses, such as is used in cattle rations, adding water when necessary. Distribute this bait over the infested field in small lumps. In case bran can not be obtained readily, middlings or alfalfa meal may be substituted. In fields known to be infested the distribution of this bait should be begun as soon as the cotton starts to appear above ground, so that the cutworms may be eliminated as quickly as possible and the skips replanted promptly. During the warmer spring months cutworms do most of their feeding at night and burrow into the soil to the depth of an inch or two during the day, so that the bait usually will be more effective if applied during the late afternoon or early evening. Frequently cutworms migrate to cultivated fields from adjoining grassland, and in such cases the crops can be protected by placing the poisoned bait around the edge of the field or along the side nearest the source of infestation.[1]

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[1] *Laphygma frugiperda* S. and A.

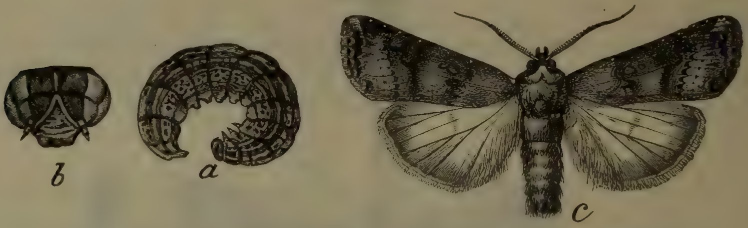

FIG. 2.—A cutworm, *Agrotis ypsilon: a*, Larva; *b*, head of same; *c*, adult moth. Natural size. (Riley and Howard.)

MAY BEETLES.[2]

In western Texas and Oklahoma several species of May beetles (figs. 3, 4) cause considerable injury to seedling cotton plants. These beetles pass the winter in the grub stage in the ground, maturing in the spring. The wingless species are especially likely to injure the cotton if it is planted on newly broken fields or fields which were very grassy in the preceding year. These forms, being unable to fly, must attack the nearest vegetation. Some of the winged species also are reported as injurious to cotton. As has already been pointed out, winter plowing is of assistance in checking these beetles. The poisoned baits recommended for cutworms are of value against them.

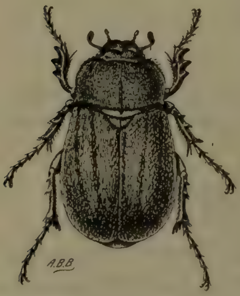

FIG. 3.—May beetle, *Phyllophaga lanceolata*. Enlarged. (Sanderson.)

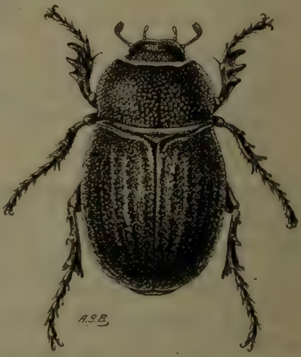

FIG. 4.—May beetle, *Phyllophaga cribrosa*. Enlarged. (Sanderson.)

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[1] Extracted from Farmers' Bulletin 739. This bait is of value in the control of other pests and will be mentioned several times in this bulletin.

[2] (*Lachnosterna*) *Phyllophaga* spp.

OTHER PESTS THAT INJURE SEEDLINGS.

Many other pests from time to time seriously affect stands of seedling cotton in various parts of the country. Occasionally an early grasshopper outbreak occurs. In parts of Alabama and Mississippi cotton stands frequently are destroyed in a night by crayfish colonies. These creatures are not insects, but belong to the class of animals called Crustacea, which includes the crabs and lobsters. As they occur only where there is a considerable amount of water underground, their control is largely a matter of drainage. They live in colonies in a large chamber at the water level and reach the surface of the ground by long "chimneys." The placing of about an ounce of carbon disulphid in each "chimney," its opening thereupon being closed, will kill the inmate. Crustaceans of another group which injure cotton seedlings are the sowbugs and pill bugs.[1] They can be controlled readily by poisoned baits.

INJURIES WHICH ABORT THE GROWTH.

COTTON APHIS.[2]

One of the earliest insects to be found on the plant is the cotton aphis or "cotton louse" (fig. 5), which also attacks many other plants. The green "lice" are not conspicuous, but the rate of multiplication is so rapid that they can become a very serious pest. They suck the juices of the plant, sometimes causing death and often a curling or dwarfing of the leaf and malformation of the plant. They are seldom of enough importance to necessitate remedial measures, but when they attack small plots of cotton planted for purposes of selection, etc., it is advisable to spray with 40 per cent nicotine sulphate used at the rate of three-fourths of a pound to 100 gallons of water. Preventive measures, such as fall and winter plowing, to destroy them on their weed host plants, are much more effective than direct remedies.

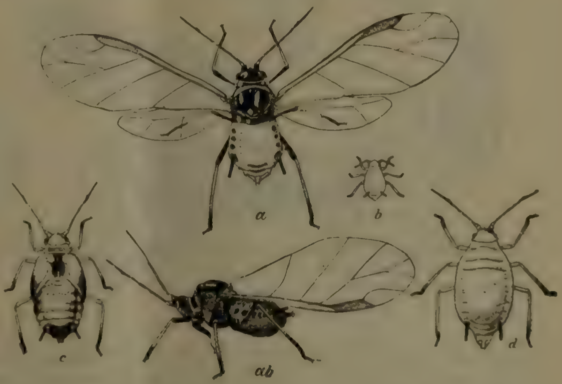

FIG. 5.—Cotton aphis: *a*, Winged female; *ab*, dark female, side view; *b*, young nymph, or larva; *c*, last stage of nymph; *d*, wingless female. All much enlarged. (Chittenden.)

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[1] *Armadillidium vulgare* Latr., *Porcellio laevis* Latr., etc.

[2] *Aphis gossypii* Glov.

SOUTHERN GRASSWORM.[1]

The southern grassworm, or fall army worm (fig. 6), is not native to the United States, although occasionally it winters over in the extreme southern portions of the country. It feeds on many plants, grasses, and cultivated crops and is often a serious pest. Winter control is of no avail, as the attack follows the flight of the moths into new territory. The larvæ work very rapidly and cause considerable injury to the plants by gnawing the stem partly in two, eating the growing tips, and causing other injuries which result in a distorted growth and dwarfing of the plant.

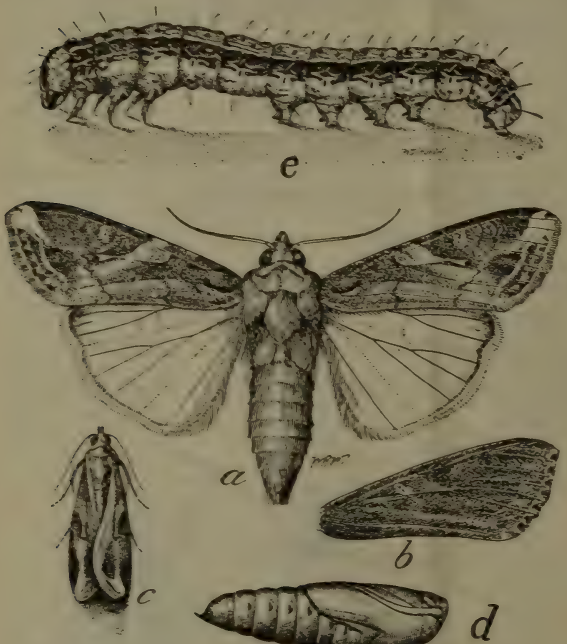

FIG. 6.—Southern grass worm, or fall army worm: *a*, Adult male moth: *b*, right front wing of female moth; *c*, moth in resting position; *d*, pupa; *e*, full-grown larva. *a*, *b*, *d*, *e*, about twice natural size; *c*, slightly enlarged. (Walton and Luginbill.)

When numerous on cotton, powdered arsenate of lead should be applied at the rate of about 5 pounds per acre. The usual method of utilizing cloth sacks on poles carried through the field on the back of a horse or mule is perfectly adapted to this crop. The following description of the construction and use of the outfit needed for this purpose is quoted from Farmers' Bulletin 872, "The Bollworm or Corn Earworm:"

A 4-inch board about 18 inches longer than the distance between the rows is used for the pole. To form the bags at either end, four blocks of the same material, each about 4 inches long, are nailed endwise to the underside of the pole. One of these is placed at each end and the other two about 16 inches from these to form the ends for the rectangular-shaped bags. An inch or one and a half inch hole is then bored through the pole about 8 inches from either end for pouring the poison into the bags. These holes are closed with corks when the outfit is in use. The sides of a rectangular piece of cloth are then tacked along each edge of the pole, and the ends to the side, and bottom of the blocks. If unadulterated Paris green is to be used, 8-ounce duck may be used for the bag, but lighter material is necessary for powdered arsenate of lead or Paris green mixed with flour. The poison sifts out over the plants as the pole is jarred by striking it with a stick as it is carried across the back of a mule ridden between the cotton rows. Two rows are thus treated at once and from 15 to 20 acres can be covered by one man during the early morning and evening hours which are suitable for the work. It is best to apply the poison when the plants are moist with dew so that it will adhere to the foliage. It is also necessary to avoid windy periods.

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[1] *Laphygma frugiperda* S. and A.

If the worms are in grass plots or cultivated fields adjoining cotton, the poisoned bait described for cutworms will be effective in keeping them from the cotton. In some cases where the ground is hard, with little vegetation, the use of heavy rollers or brush will be of advantage in crushing the worms. Deep furrows around the field will catch many worms moving into a field and in these they may be crushed.

When they are full grown they enter the soil and change to pupæ. A shallow cultivation by disking or with a spring-tooth harrow at this time is very effective, as it will kill many pupæ and expose others to the heat of the sun.

INJURIES TO THE GROWING TIP.

The growing tip of cotton frequently is injured by insects which make their principal attack on other parts. The boll weevils in the spring frequently injure the terminal bud when they emerge from hibernation before the squares form. Grassworms, cutworms, and grasshoppers do similar injury. Frequently small "worms" which make a web around the leaf or bud are to be found. These belong to several different genera[1] of moths and are not often of grave importance. As they are usually insects which normally attack some weed, another argument for weed control and fall plowing is afforded.

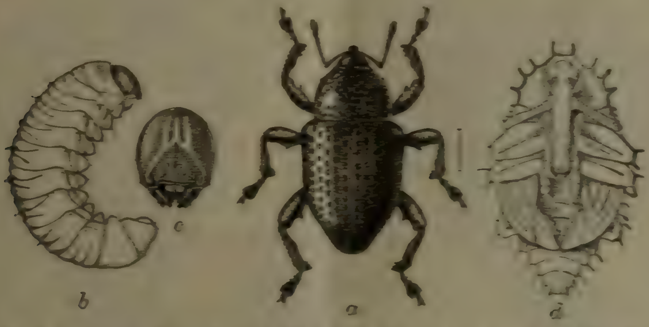

Fig. 7.—Cowpea-pod weevil: *a*, Adult weevil; *b*, larva, side view; *c*, head of same, front view; *d*, pupa, viewed from below. Much enlarged. (Chittenden.)

The cowpea-pod weevil[2] (fig. 7) frequently attacks young cotton and causes injury by puncturing the terminal bud. These attacks usually occur when cotton follows cowpeas.

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[1] Platynota, Loxostege, etc.

[2] *Chalcodermus aeneus* Boh.

LEAF INJURIES AND DEFOLIATION.

Cotton leaves are attacked by many insects, some of which are usually considered of little importance, although in small areas they frequently do serious injury. Dusting with arsenate of lead is probably the best general remedy for cotton defoliators, such as beetles, "worms," and grasshoppers. This may be done by the pole-and-bag method or by the use of a dust gun with a rotary fan.

COTTON LEAFWORM.[1]

The best known defoliator of cotton is the cotton leafworm (fig. 8), sometimes called the cotton army worm. It is not present in the country every year. It is a native of tropical regions, but from time to time it flies to this country and often by the end of the season has stripped the cotton fields of foliage. The moths are tawny, with a wing expanse of slightly more than an inch. They lay small green eggs singly on the leaves of cotton. The larvæ are elongate, somewhat variable in coloring, some being yellowish green without prominent stripes, while others have a black stripe down the back with a fine central yellow stripe. Each segment has four black dots above. The larva when full grown webs one or two leaves together to form a cocoon and pupates therein, hanging the pupa by a thread to the stem. As the worms do not attack other plants and do not enter the ground, cultivation and weed control are of no avail against this species. When the attack is late in the season the defoliation is often beneficial, as it hastens the ripening of the fruit and cuts off the food supply of the boll weevil. But often the worms appear so early as to be capable of inflicting serious damage, especially to late crops. In such cases it is advisable to dust with arsenate of lead at the rate of about 4 pounds to the acre, more or less, depending on the size of the cotton. It is best to apply the poison when the leaves are moist with dew and when the winds are low. The planter should not wait until the defoliation is heavy.

GRASSHOPPERS.

Frequently the cotton fields of Texas and sometimes of the other cotton States are seriously injured by grasshoppers, among which the differential grasshopper[2] (figs. 9, 10) and the Southwestern lubber grasshopper[3] (fig. 11) are the most injurious.

These insects lay their eggs in masses in the ground and therefore are subject to control by cultivation where that is possible. The grasshoppers usually advance on cotton fields from near-by waste places. Where young grasshoppers appear in great numbers they may be controlled by spraying with kerosene or crude oil, trapped by the poisoned bait mentioned for cutworms, or crushed by drags or

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[1] *Alabama argillacea* Hübn.

[2] *Melanoplus differentialis* Thos.

[3] *Brachystola magna* Gir.

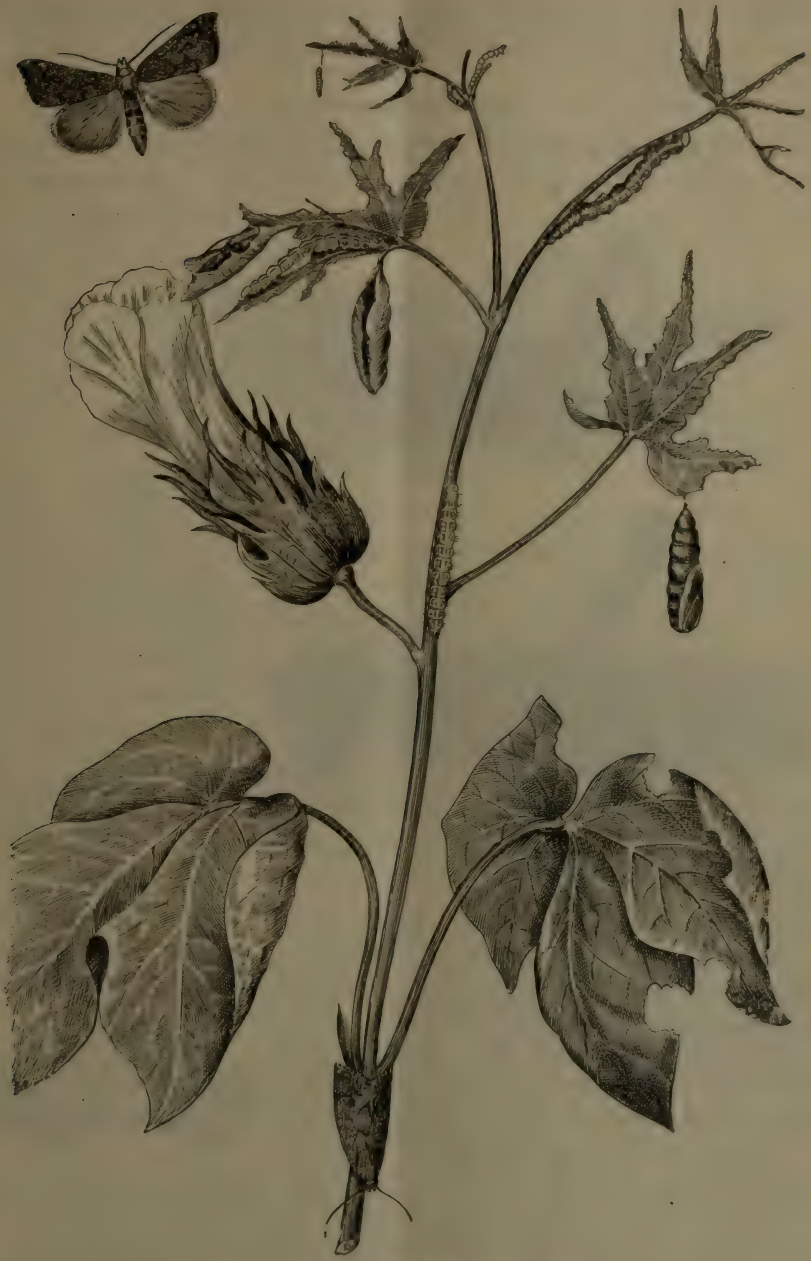

FIG. 8.—Cotton leafworm: Stages and work.

rollers. When the lubber grasshoppers appear, control measures must be taken immediately, because these insects can destroy a plant very quickly.

COTTON RED SPIDER.[1]

One of the most destructive enemies of cotton is the red spider (figs. 12–15), which is not an insect, but a mite. These mites can hardly be seen on the cotton leaf, except by a trained eye or with the aid of a magnifier, unless very numerous, when their minute moving red bodies make them distinguishable. They multiply so rapidly that they may spread from a single infested weed over an entire cotton field during the season. They suck the juices and cause the leaf to turn red and finally kill the plant. They usually work on the underside of the leaf. As the red spider is dependent on other plants to carry it through the winter, it is apparent that weed control is a very important element in reducing damage by this pest. Special bulletins are available for those desiring complete information.[2]

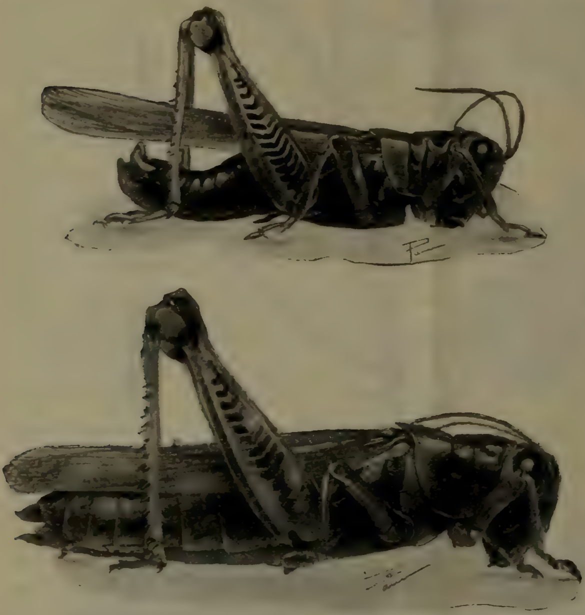

FIG. 9.—Differential grasshopper: Above, adult male; below, adult female. Twice natural size. (Walton.)

The destruction of weeds, especially the pokeweed, and of cultivated plants such as the violet, from which the mites make their way to the cotton, and the destruction by plowing up and burning of early infested cotton plants are effective measures, which should be used as primary means of control.

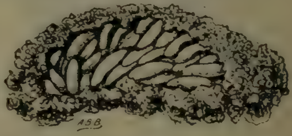

FIG. 10.—Egg mass of differential grasshopper. Enlarged. (Sanderson.)

When a cotton field is threatened by the red spider it is often advisable to spray. The following sprays are effective: (1) Potassium sulphid (1 ounce to 2 gallons of water); (2) lime-sulphur solution

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[1] *Tetranychus telarius* L.

[2] Department Bulletin 416, "The Red Spider on Cotton," and Farmers' Bulletin 831, "The Red Spider on Cotton and How to Control it."

(homemade or commercial); (3) kerosene emulsion[1]; (4) flour-paste solution (1 gallon stock paste to 12 gallons water).

LEAF-CUTTING ANT.[2]

The so-called leaf-cutting or parasol ant is well known in southwestern Texas, where it is often destructive to cultivated crops, including cotton. The ants cut the leaves from a plant and carry them to the nest The leaves are finely divided and made into small pellets, by means of the mandibles and legs. The pellets are placed upon the so-called fungus garden, where they furnish a growing medium for the fungus on which the colony feeds.

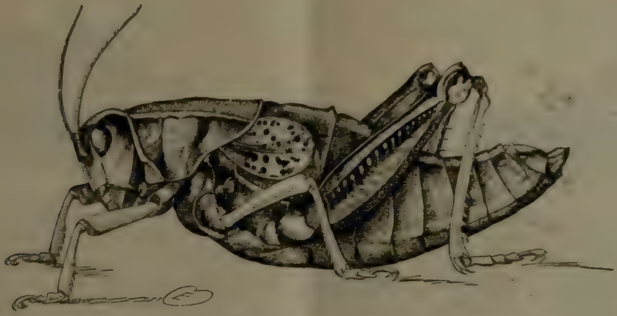
FIG. 11.—Southwestern lubber grasshopper; Adult female, natural size. (Walton.)

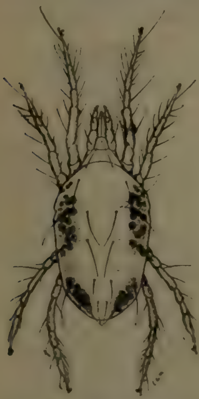
FIG. 12.—The female red spider. Highly magnified. (McGregor and McDonough.)

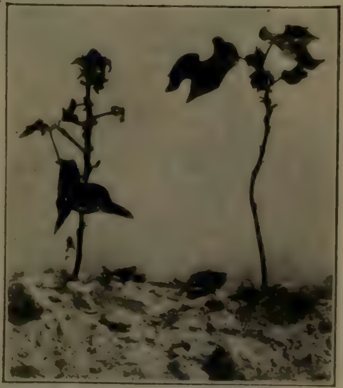
FIG. 13.—Cotton plant in well advanced stage of infestation by the red spider. Nearly all leaves, squares, and bolls have been shed. (McGregor.)

The best method of control is by means of potassium or sodium cyanid, a deadly poison. The cyanid is used at the rate of 1 ounce to 1 quart of water. After careful mixing the liquid is poured into each opening of the nest, a quart to an opening. Two applications may be necessary to exterminate the colony. *Care must be taken not to breathe*

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[1] Kerosene emulsion is made by combining 1 gallon of kerosene and one-fourth pound of laundry soap, or 1 pound of whale-oil (fish-oil) or other soap, or 1 pint of soft soap, with half a gallon of water. The laundry soap, if dry, is shaved and dissolved in boiling water and then poured (away from the fire) while still boiling hot into the kerosene. The mixture is then churned rapidly 8 or 10 minutes, the liquid being pumped back upon itself by means of a sprayer with a nozzle throwing a strong, solid stream. At the end of this time the mixture becomes a thick cream—the stock emulsion. In the preparation of the emulsion a sprayer is necessary. For most species of sucking insects 1 part of the stock emulsion should be mixed with 15 parts of water.

[2] *Atta texana* Buckley.

the deadly fumes of this poison. Gloves should be used in handling this poison to prevent any of it from coming in contact with abrasions of the skin. The action of the poison on the blood is more deadly than the fumes which might be breathed in the handling, when done out of doors. All refuse should be buried immediately, and the hands washed carefully.

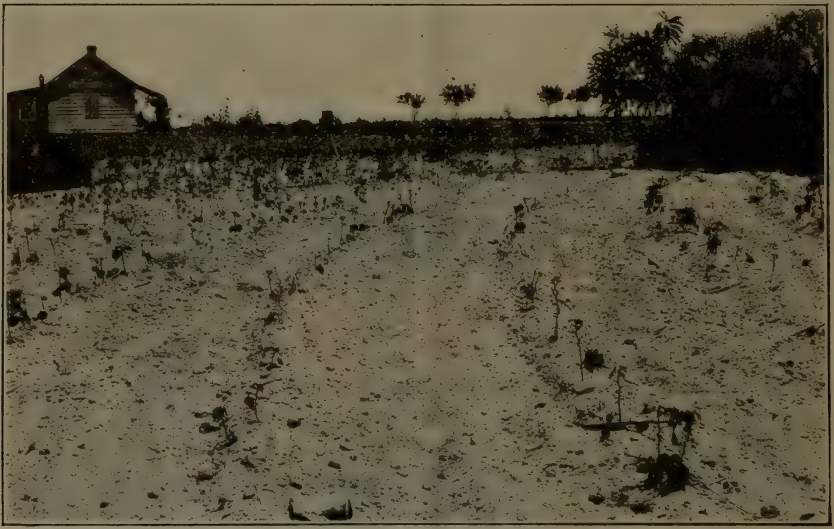

FIG. 14.—A severe example of red-spider work in a cotton field. Nearly all plants in the foreground are in the condition shown in figure 13. The source of infestation was certain pokeweed stalks growing in the weed border seen in the upper right-hand corner of the picture. (McGregor.)

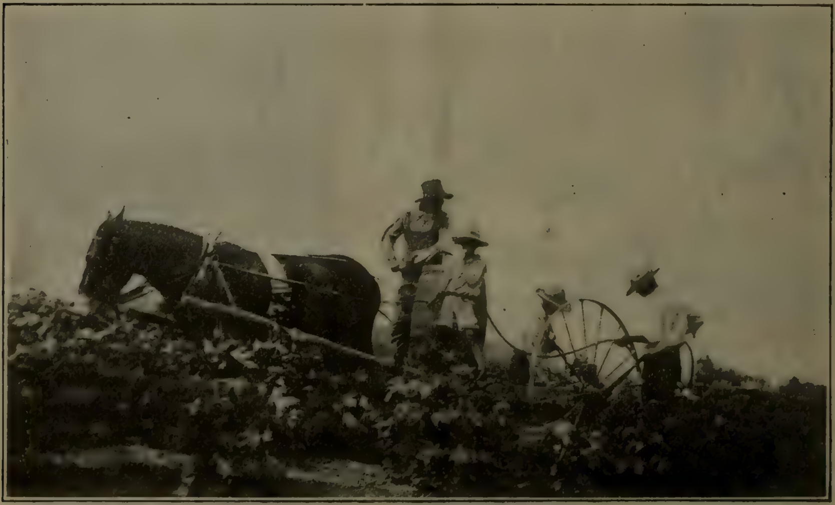

FIG. 15.—Ideal spraying outfit for treatment of considrable red-spider infestation. (McGregor.)

SALT-MARSH CATERPILLAR.[1]

The salt-marsh caterpillar (fig. 16) is one of the species of "woolly-bears," several of which may at times seriously injure cotton. This species is almost always to be found in the fields. The eggs are laid in masses. The larvæ are covered with long hairs and are somewhat variable in color. They feed on many kinds of foliage and usually come to the cotton fields from some adjoining weedy area. The larvæ when full grown spin a silken cocoon surrounded by rubbish, on the ground or among the leaves of the plant.

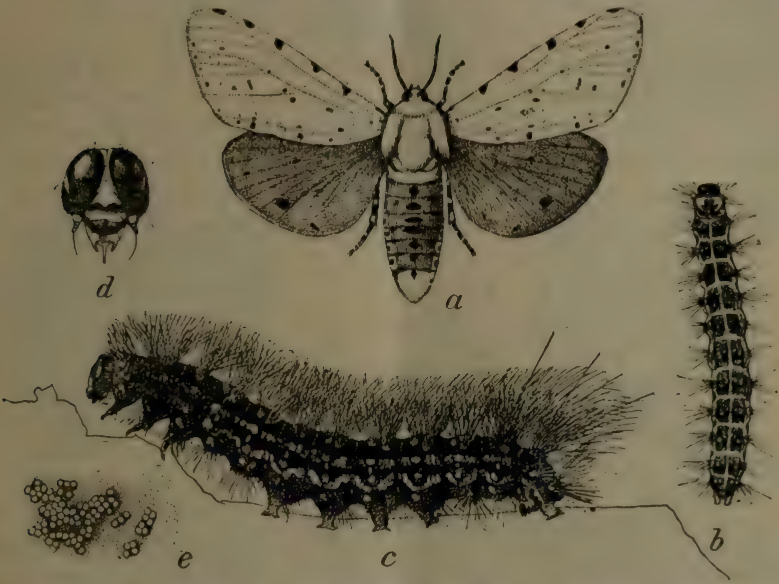

FIG. 16.—Salt-marsh caterpillar: *a*, Female moth; *b*, half-grown larva, or caterpillar; *c*, full-grown larva, side view; *d*, head of larva, front view; *e*, egg mass. All slightly enlarged, except *d*, which is more enlarged. (Chittenden.)

Control of the weeds around the field is naturally the best way of preventing damage by this species and its allies.

OTHER LEAF EATERS.

Many other kinds of caterpillars occasionally injure cotton, such as that of the large tiger moth,[2] the beet army worm,[3] the fall web-worm,[4] and that of the io moth.[5] The larvæ of the io moth are green and covered with poisonous spines. They are very pretty and also well known, to all who have ever touched them, as "stinging caterpillars." They cause a very painful rash when touched. If abundant enough to warrant it, all of these insects can be controlled by dusting the plants with arsenate of lead, but they will not be serious if proper attention is given to surrounding vegetation on which they feed normally.

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[1] *Estigmene acraea* Dru.

[2] *Apantesis arge* Dru.

[3] *Caradrina exigua* Hübn.

[4] *Hyphantria cunea* Dru.

[5] *Hyperchiria io* Fab.

HOW INSECTS REDUCE THE YIELD.

Naturally the most serious injury to the cotton crop is that which affects the squares, flowers, and bolls, and among the insects causing this injury are some of the most serious known insect pests.

COTTON-BOLL WEEVIL.[1]

The worst cotton pest in this country, and probably the most destructive cotton insect in the world, is the Mexican cotton-boll weevil (figs. 17, 18), which annually takes a toll of tens of millions of dollars from the cotton industry. As this insect is of such great importance, many bulletins have been written about it, and the most recent of these may be obtained on application to the Division of Publications, United States Department of Agriculture, Washington, D. C. The boll weevil lays its eggs in the squares and bolls. Generally the squares which have been attacked will fall to the ground in a few days. They always flare and often hang and dry on the plant. The eggs hatch into small white grubs, or larvæ, with yellowish-brown heads. These feed in the square or boll and grow until they are half an inch long. They usually are curved and are legless. When full grown the grub forms a hard cell and turns into a pupa, which matures in about three days into the adult weevil.

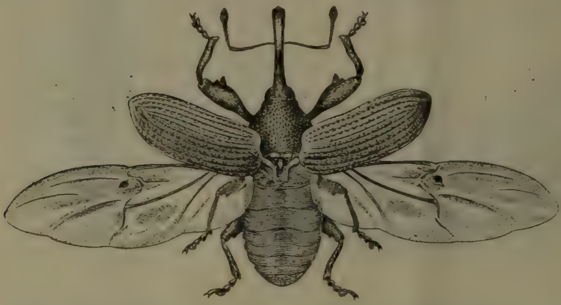

FIG. 17.—Adult female boll weevil with wings spread. Much enlarged. (Hunter and Pierce.)

The weevil is easily detected in a field. If a square is found with its bracts flared and showing a little wartlike puncture, it can be put into a tumbler and covered with cheesecloth. After 2 or 3 days the white larva can be easily found, and in about 10 or 12 days the full-grown weevil will come out.

The control of the weevil is brought about by early planting, selection of the best local varieties, intensive cultivation, early picking of the crop, and destruction of the cotton plants, or at least destruction of the green growth, before frost. All of these methods will also help in controlling the other cotton pests.

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[1] *Anthonomus grandis* Boh.

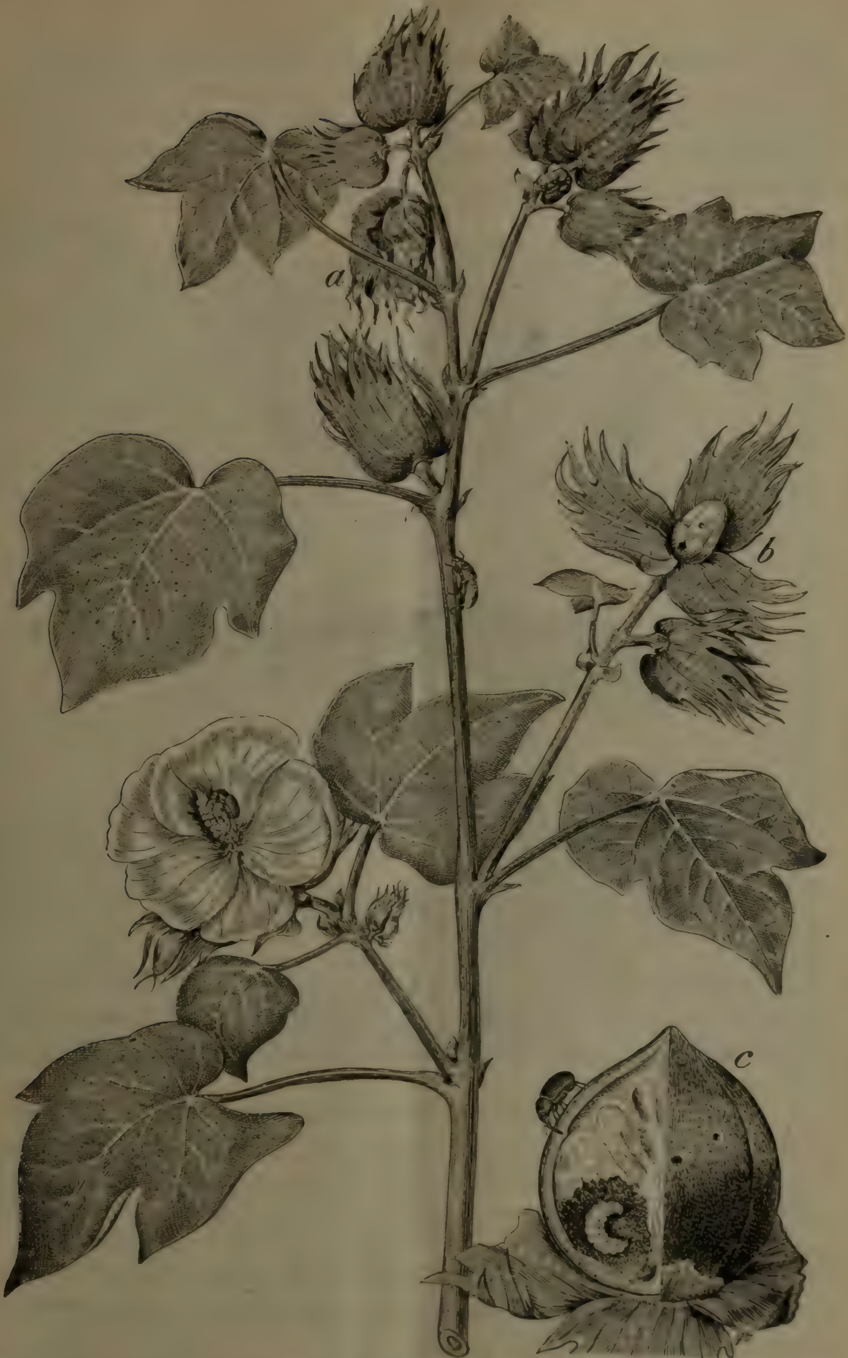

FIG. 18.—Cotton plant attacked by boll weevil: *a*, Hanging dry square infested by weevil; *b*, flared square, with weevil punctures; *c*, cotton boll, sectioned, showing attacking weevil and weevil larva in its cell. (Hunter and Pierce.)

BOLLWORM.[1]

The well-known bollworm (figs. 19, 20) is called the corn ear-worm when it attacks the ears of corn. It is likewise a pest of tomatoes, tobacco, beans, and alfalfa. The eggs are laid singly. The larvæ bore into the squares and bolls and eat out the interior, usually leaving by another hole and going to another square or boll. Thus a single worm during its development may injure all the forms on several branches. When full grown, it enters the ground for pupation, emerging in about two weeks as a moth. The bollworms pass the winter as pupæ in the soil.

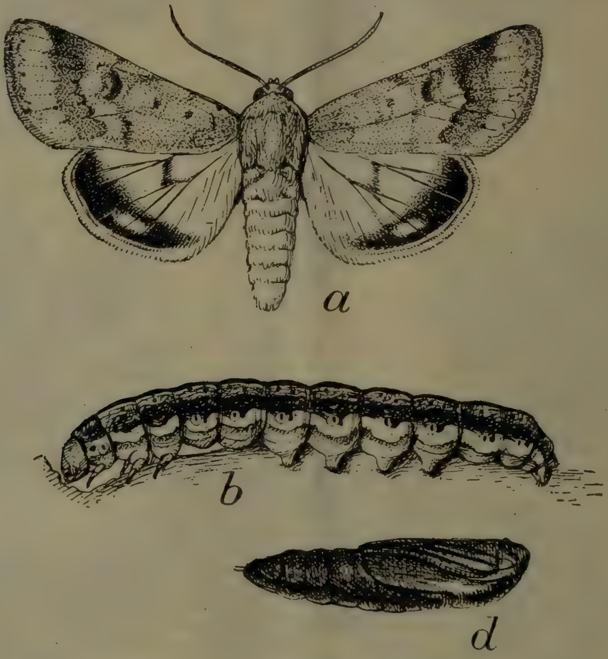

FIG. 19.—Bollworm: *a*, Moth, or adult; *b*, larva, or worm; *d*, pupa. About natural size. (Howard.)

Thorough plowing of the land during the fall and winter and frequent cultivation of the growing crop will destroy many bollworm pupæ and expose others to the action of rain and frost, sunshine, and insect enemies, and to insect-eating birds and rodents. In combatting the bollworm as well as the weevil an early crop is necessary. If its attack is very serious, poisoning with powdered arsenate of lead by the pole-and-bag method, described under "Southern grass worm," p. 8, is to be recommended.

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[1] (*Heliothis*) *Chloridea obsoleta* Hübn.

COTTON SQUARE-BORER.[2]

Frequently the squares are bored by small, oval, flattened, pea-green, velvety-haired larvæ, known as square-borers (fig. 21). Each larva can destroy many squares. The larvæ transform into small pupæ, and when mature these become the dainty little blue swallow-tailed butterflies so often seen in the cotton fields. It is seldom necessary to take active measures against them, but when advisable powdered arsenate of lead is recommended.

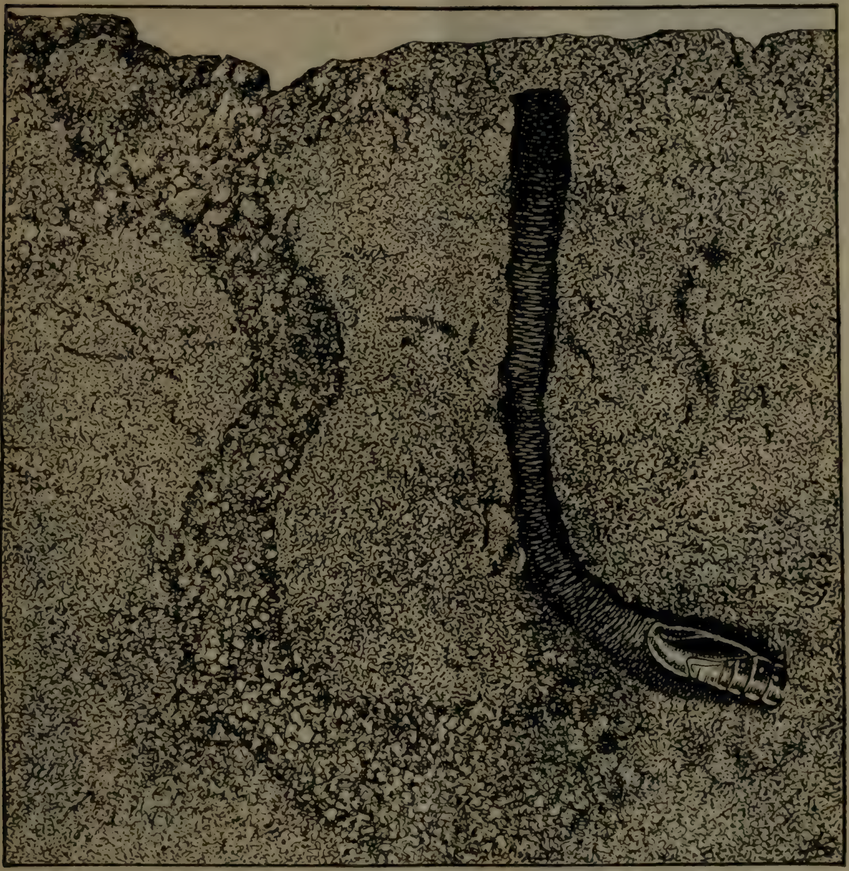

FIG. 20.—Vertical section through the soil, showing pupa of bollworm in its burrow. (Bishopp and Jones.)

COTTON-BOLL CUTWORM.[2]

The cotton-boll cutworm (figs. 22, 23) looks like an ordinary cutworm but it feeds by day on the foliage and bores into squares and bolls. The larvæ are olive or greenish brown and easily recognized by the

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[1] *Uranotes melinus* Hübn.

[2] *Prodenia ornithogalli* Guén.

two rows of triangular velvety-black spots extending down the back. Four or five broods a year occur in Texas. By picking them off of young cotton when chopping in the spring they may be largely controlled. As they pupate in the soil, frequent cultivations destroy the pupæ.

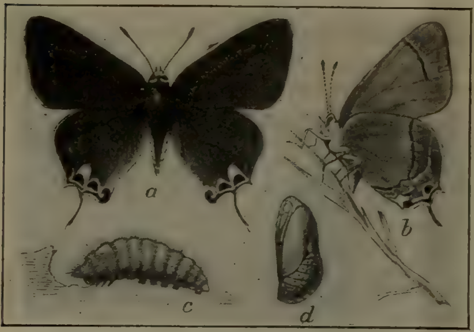

FIG. 21.—Cotton square-borer: *a*, Adult butterfly, top view; *b*, same from side, with wings closed; *c*, larva, or borer, from side; *d*, pupa; *e*, egg. *a–d*, Somewhat enlarged; *e*, greatly enlarged. (Howard.)

COTTON STAINER.[1]

The cotton stainer (fig. 24) is important only in the Southeast, especially in Florida. It is a sucking bug with a long beak. The body is red, with dark-brown or black wings. It feeds on the juices of many plants. The young are similar to the adult except that the wings are not developed. Much injury is done to cotton by the staining of the fiber. In sections where this bug is abundant, measures should be taken to hold down the growth of weeds, upon which the stainer breeds in great numbers. Principal among these weeds are Spanish cocklebur[2] and nightshade.[3] They may be trapped by placing small bunches of cotton seed in different parts of the field.

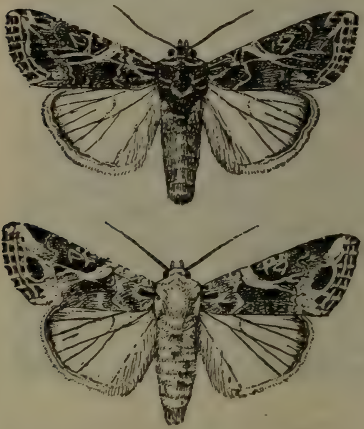

FIG. 22.—Cotton-boll cutworm: Above, dark form of moth, male; below, pale form of moth, female. Somewhat enlarged. (Chittenden.)

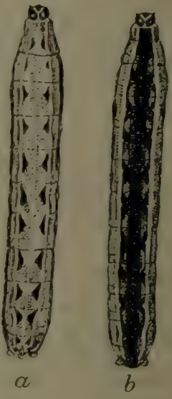

FIG. 23.—Cotton-boll cutworm: *a*, Light form of larva; *b*, dark form of larva. Somewhat enlarged. (Chittenden.)

As soon as the young bugs make their appearance in the spring, the colonies should be sprayed with kerosene emulsion, or jarred into buckets of water having a film of kerosene.

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[1] *Dysdercus suturellus* H. Schf.

[2] *Urena lobata.*

[3] *Solanum nigrum.*

COTTON BUGS.

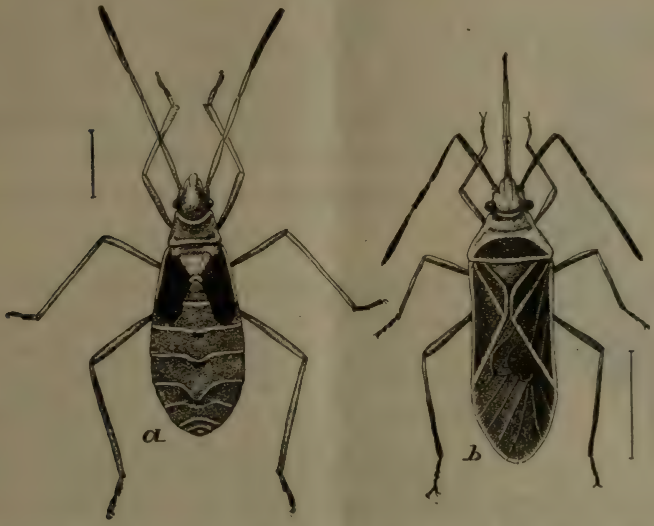

FIG. 24.—Cotton stainer: *a*, Fourth-stage nymph, or pupa; *b*, adult. Enlarged. (Insect Life.)

Many different species of sucking bugs[1] attack the cotton squares and bolls and do serious injury. Many of them are known as "pumpkin bugs" and "stinkbugs," but most of them are simply called plant-bugs.

Usually they breed on many plants besides cotton and are kept under control best by preventing excessive weed growth around cotton fields. It has been proved that some of these bugs carry plant diseases of cotton, and hence they are to be regarded as serious pests. Several species are illustrated (see figs. 25–29).

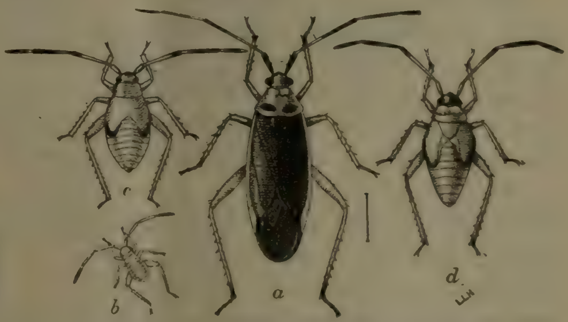

FIG. 25.—Cotton leaf-bug, *Adelphocoris rapidus*: *a*, Mature bug; *b*, young nymph; *c*, fourth stage of nymph; *d*, fifth stage of nymph. Much enlarged. (Sanderson.)

FLOWER BEETLES.

Frequently beetles are found in the blooms of cotton, and occasionally they are numerous enough to do much damage. The blister beetles[2] (see fig. 30) and soldier beetles[3] feed on the petals and eat the pistil and stamens. In case of injury to the pistil the boll frequently fails to mature. These insects in their immature stages prey on other insects and are beneficial.

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[1] *Adelphocoris rapidus* Say, *Leptoglossus phyllopus* L., *Largus succinctus* L., *Nezara hilaris* Say, *Jadera haematoloma* H.-Schf., etc.

[2] *Epicauta vittata* Fab., *E. lemniscata* Fab., *E. cinerea* Forst., *E. ferruginea* Say, etc.

[3] *Chauliognathus* spp.

LEAF BEETLES.

A number of small leaf beetles—some brown, some blue, some green, or striped with yellow—occur on cotton squares and feed on the bracts or sometimes eat the leaves of cotton. They are native to weeds around the fields, and are seldom important.

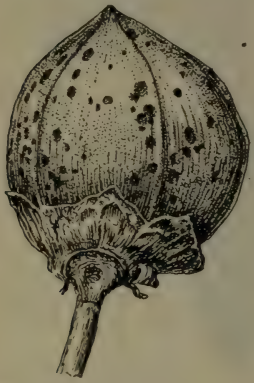

FIG. 26.—Cotton boll showing punctures of a cotton leaf-bug, *Adelphocoris rapidus*. (Sanderson.)

INJURIES TO THE STALK AND ROOTS.

COTTON WIREWORMS.

In South Carolina much injury is done to the roots of cotton by wireworms[1] (see fig. 31). The adults of these worms are the well known click-beetles so abundant at the flowers and squares of cotton. They are controlled best by using a crop rotation in which cotton follows oats and corn follows cotton. The oats stubble should remain on the land until September 15. After this time it is well to prepare the land and plant a winter cover crop. The cover crop should be supplemented with stable manure, swamp muck, or lime, as it is necessary to build up soil infested by wireworms.

CORN ROOT-APHIS ON COTTON.[2]

Especially in South Carolina the cotton is attacked at the roots by the root-aphis of corn. This insect is similar in appearance to the cotton aphis but confines its attacks to the taproot of cotton. The best control is a three-year system of rotation in which cotton does not follow either corn or cotton. Small grain or cowpeas should precede cotton on badly infested lands. The three-year rotation of oats and cowpeas, cotton, and corn has proved successful. It is of great value to have a winter cover crop on infested lands at all times, as it prevents the winter food plants of the cotton root-aphis from growing upon the land.

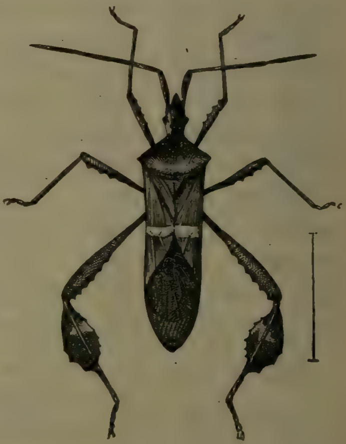

FIG. 27.—Leaf-footed plant-bug (*Leptoglossus phyllopus*) twice natural size. (Hubbard.)

---

[1] *Monocrepidius vespertinus* Fabricius, *Horistonotus uhlerii* Horn, and related species. For an account of these and other species see Farmers' Bulletins 725 and 733.

[2] *Aphis maidiradicis* Forbes.

MOTH STALK-BORER.[1]

Occasionally cotton stalks are bored by the caterpillar of the stalk-borer (fig 32). Ordinarily it attacks various weeds, including "bloodweed."[2] Weed destruction, therefore, is the obvious control measure.

COTTON STALK-BORER BEETLE.[3]

The cotton stalk-borer beetle sometimes is found in Texas boring in cotton stalks, but it is supposed to attack only plants damaged by some other agency.

SNOWY TREE CRICKET.[4]

In the fall of the year cotton stalks frequently are found with the stems roughened by the egg punctures of the snowy and other tree crickets. These tree crickets also oviposit in weeds. They pass the winter in the egg stage in the old stalks and in the spring the young crickets hatch. They feed on vegetation of all kinds. Fall destruction of cotton stalks and weeds is a practical control measure.

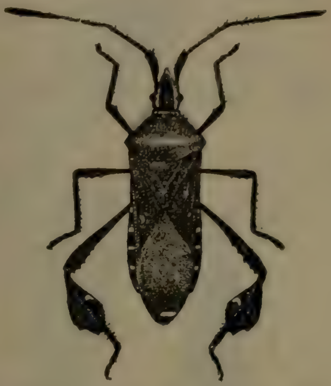

FIG. 28.—A plant-bug, *Leptoglossus oppositus*. Twice natural size. (Chittenden.)

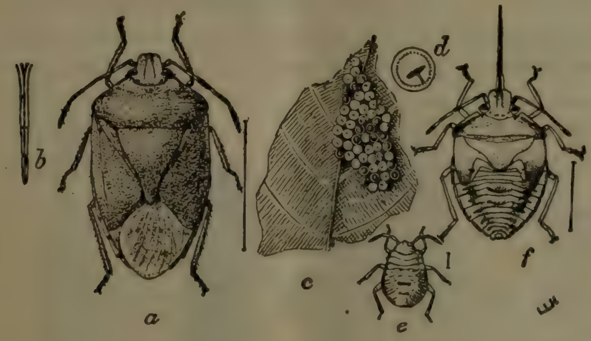

FIG. 29.—The green soldier bug (*Nezara hilaris*): *a*, Mature bug; *b*, beak of same; *c*, egg mass; *d*,single egg; *e*, young nymph; *f*, last stage of nymph. All enlarged; *b*, *d*, more enlarged. (Sanderson.)

SHARPSHOOTERS.[5]

The leafhoppers seen so frequently on the cotton stalks (see figs. 33–36) in the late summer and fall, dodging out of sight around the stem, are commonly called "sharpshooters" with the doubtful assumption that they puncture the squares and bolls. They do puncture the stalks and lay their eggs in the leaves just under the surface, forming a blisterlike mark.

---

[1] *Papaipema nitela* Guén.

[2] *Ambrosia trifida* and other species of Ambrosia.

[3] *Ataxia crypta* Say.

[4] *Oecanthus niveus* DeG.

[5] *Homalodisca triquetra* Fab., *Oncometopia undata* Fab., *Oncometopia lateralis* Fab., and *Aulacizes irrorata* Fab.

INSECTS IN DECAYED AND DRY BOLLS.

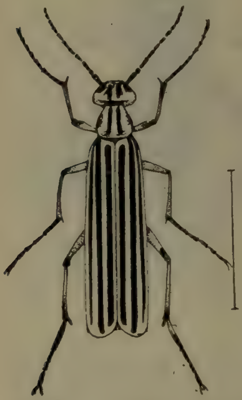

FIG. 30.—A blister beetle, *Epicauta lemniscata*. Enlarged. (Chittenden.)

Cotton bolls which have become affected by anthracnose and other diseases furnish an attraction to many bugs and beetles, which no doubt often are instrumental in spreading the infection. Very few of these insects found feeding in the rotten spots have any primary importance to the cotton plant. Dry bolls which have matted fiber are often filled with small beetles, little white "worms," and larger pink "worms." These are all feeders on decayed matter. (The pink "worms" are not to be confused with the pink bollworm[1] of cotton which ultimately may become a pest in this country, the larvæ of which will be found in the winter in bolls with healthy fiber, in seeds, or in cells formed by uniting two seeds.) Boll-weevil larvæ, pupæ, and adults frequently may be found in cells in old bolls, which in addition may serve as shelter for other pests. As some of the insects which are merely scavengers in cotton bolls are recorded as injurious on other plants, it is important that all cotton plants be disposed of as soon after the cotton is picked as is practicable.

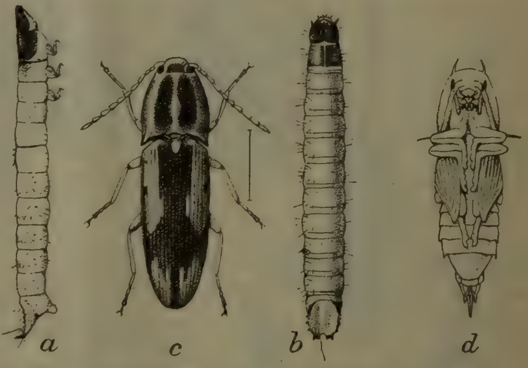

FIG. 31.—A cotton wireworm, *Monocrepidius vespertinus*: *a*, Larva, or wireworm, side view; *b*, same, top view; *c*, adult, or beetle; *d*, pupa. Much enlarged. (Chittenden.)

THE DOUBLE RÔLE OF ANTS.

Of course every cotton field has its ant colonies. When the ants are large species, such as the leaf-cutting ant[2] or the Texas agricultural ant,[3] the colonies should be destroyed as described under the paragraph on the former (p. 13). The smaller ants which swarm over the cotton plants are very helpful in ridding the plant of many enemies, for they attack in numbers insects much larger than themselves. Several species of ants[1] are very efficient enemies of the boll weevil.

---

[1] *Pectinophora gossypiella* Saunders.

[2] *Atta texana* Buckley.

[3] *Pogonomyrmex barbatus molefaciens* Buckley.

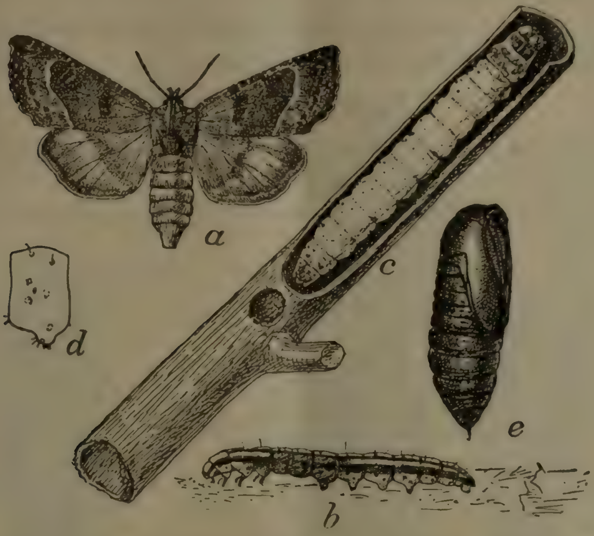

FIG. 32.—Moth stalk-borer: *a*, Female moth; *b*, half-grown larva, or borer; *c*, full-grown larva in injured stalk; *d*, side view of segment of abdomen of same; *e*, pupa. All somewhat enlarged. (Chittenden.)

They eat their way into fallen infested squares and devour the weevil larvæ, pupæ, and adults. In this way they often add 10 to 20 per cent to the natural control of the weevil. But these same ants are fond of sweets and they foster the honeydew-secreting aphids, white flies, and scales, which are found on cotton, transplanting them to new colonies. They are diligent in protecting the aphids, or "lice," from voracious enemies and in this way become enemies of the cotton planter. On the whole, however, it is believed that the smaller ants do at least as much good as harm and should be let alone.

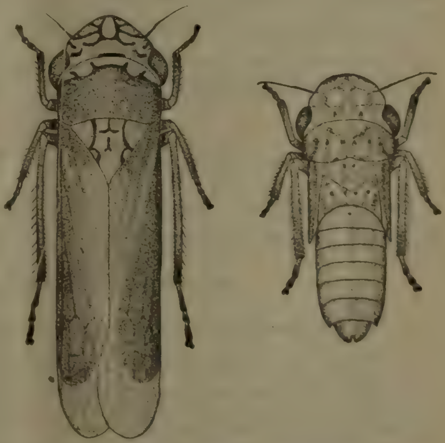

FIG. 33.—A "sharpshooter," ***Oncometopia undata:*** Adult at left, nymph, or young, at right. Greatly enlarged. (Sanderson.)

THE PARASITES.

Practically all of the pests mentioned on other pages are held more or less in control by other insects which prey on them or live at their expense. The little parasites are so inconspicuous that they seldom are seen, but often their work is very effective. All the measures which are recommended for the control of the various pests, except the use of poisons, will serve to favor parasite attack, which will go on without other effort by the planter.

---

[1] Especially species of Solenopsis, Pheidole, Monomorium, and Iridomyrmex.

INSECT VISITORS OF COTTON.

Many of the wasps and bees that visit cotton are there only for nectar or pollen and incidentally they serve to fertilize the plants. It is thus that most of our plants are fertilized. The nectar attracts multitudes of insects which have nothing to do with cotton otherwise. When weeds are allowed to grow and nourish pests and are suddenly cut or destroyed, one may expect a large increase of insects on cotton, many of which will be injurious. *The weeds must not be allowed to grow.*

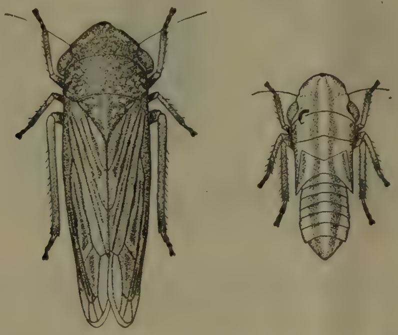

FIG. 34.—A "sharpshooter," *Oncometopia lateralis:* Adult at left; nymph, or young, at right. Greatly enlarged. (Sanderson.)

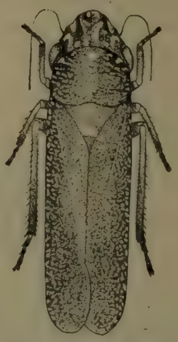

FIG. 35.—A "sharpshooter," *Aulacizes irrorata:* Adult. Greatly enlarged. (Sanderson.)

SUMMARY OF CONTROL MEASURES.

In summary of the preceding paragraphs a single system may be devised for cotton-insect control.

BEST MEASURES FOR THE EARLY SPRING.

1. Keep down weed growth around the farm.
2. Plow in the winter to break up the winter cells in the ground.
3. When necessary set out poisoned baits to trap cutworms, grasshoppers, May beetles, etc.
4. Plant as early as it can be done safely and yet avoid killing frosts. Plant the variety which is found to be the best producer in your own locality, and which has the qualities of rapid and prolific fruiting.
5. Space the rows in accordance with local experience
6. Cultivate frequently, but not deeply.

BEST MEASURES TO FOLLOW DURING THE SUMMER.

1. Continue cultivation until the crop is made, or as long as possible.
2. Watch for the first appearance of worms.
3. Dust the cotton with powdered arsenate of lead as soon as grasshoppers or “worms” begin to attack, unless “worm” attack starts late and would hasten ripening.
4. Keep down the weeds.

WHAT TO DO IN THE FALL.

1. Pick the cotton out as soon as possible.
2. Destroy the plants by plowing under or grazing as long before frost as possible.
3. Where practicable plow the fields and plant a cover crop.
4. Where feasible follow a three-year rotation with cotton following some crop other than corn.

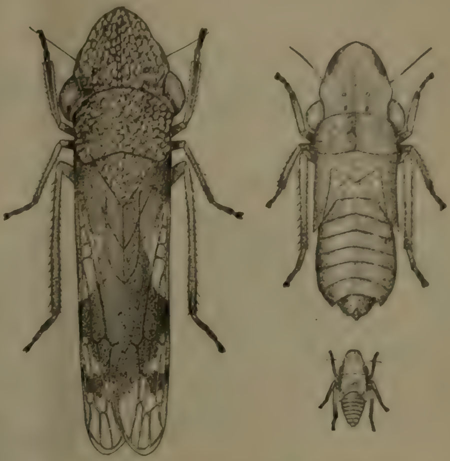

FIG. 36.—A “sharpshooter,” *Homalodisca triquetra:* Adult at left; last-stage nymph, or young, at right, above; young nymph at right below. Greatly enlarged. (Sanderson.)

PRACTICAL MEASURES FOR THE WINTER.

1. Clean up all turn rows and fence rows.
2. Cut and burn all weeds.
3. Plow under all stubble fields that are not to be used otherwise.
4. Grub up old stumps.

PUBLICATIONS OF U. S. DEPARTMENT OF AGRICULTURE RELATING TO INSECTS INJURIOUS TO COTTON OTHER THAN THE BOLL WEEVIL.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Fall Army Worm, or "Grass Worm," and its Control. (Farmers' Bulletin 752.)
Red Spider on Cotton and How to Control it. (Farmers' Bulletin 831.)
Carbon Disulphid as an Insecticide. (Farmers' Bulletin 799.)
Bollworm or Corn Earworm. (Farmers' Bulletin 872.)
The Argentine Ant: Distribution and Control in the United States. (Department Bulletin 377.)
The Red Spider on Cotton. (Department Bulletin 416.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Miscellaneous Cotton Insects in Texas. (Farmers' Bulletin 223.) Price, 5 cents.
Two Destructive Texas Ants. (Entomology Circular 148.) 1912. Price, 5 cents.
Cotton Stainer. (Entomology Circular 149.) 1912. Price, 5 cents.
Cotton Worm or Cotton Caterpillar. (Entomology Circular 153.) 1912. Price, 5 cents.
Report on Miscellaneous Cotton Insects in Texas. (Entomology Bulletin 57.) 1906. Price, 5 cents.
Cotton Stalk-borer. (Entomology Bulletin 63, pt. VII.) 1907. Price, 5 cents.
Mexican Conchuela in Western Texas in 1905. (Entomology Bulletin 64, pt. I.) 1907. Price, 5 cents.
Notes on Economic Importance of Sowbugs. (Entomology Bulletin 64, pt. II.) 1907. Price, 5 cents.
Plant-bugs Injurious to Cotton Bolls. (Entomology Bulletin 86.) 1910. Price, 20 cents.
Argentine Ant. (Entomology Bulletin 122.) 1913. Price, 25 cents.

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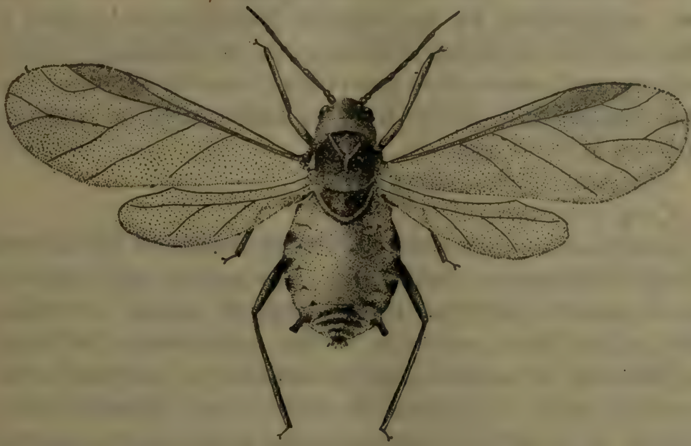
THE CORN ROOT-APHIS AND METHODS OF CONTROLLING IT

JOHN J. DAVIS
Entomological Assistant, Cereal and Forage
Insect Investigations



Winged female of corn root-aphis (form that produces living young). Greatly enlarged

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FARMERS' BULLETIN 891

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. December, 1917

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1917

CONTROL of the corn root-aphis, which can be accomplished by the simple practices described in this bulletin, is important because, in addition to corn, cotton, and asters, this insect feeds on the roots of certain weeds and everywhere is fostered by a common species of field ant.

The control measures are—

Crop rotation.

Early and deep spring plowing followed by several deep diskings to demoralize the aphid and ant colonies and to prevent the growth of weeds on which the aphis lives previous to the appearance of corn.

The use of a substance possessing a pungent odor, applied with a chemical fertilizer and distributed by means of a fertilizer attachment to the corn planter, to repel the ants and prevent them from placing aphids on the roots of the corn or other cultivated crop.

The use of barnyard manure or other fertilizer as an aid in producing stronger plants. Though this does not reduce the number of aphids, directly or indirectly, it enables the plants to withstand injury better. It is recommended only as supplementary to the practices already mentioned.

THE CORN ROOT-APHIS[1] AND METHODS OF CONTROLLING IT.

CONTENTS.

	Page.
The corn root-aphis and its injury	3
Seasonal history and habits	5
Relation between ants and the aphids	8
Past history	9
Methods of control	10
Rotation of crops	10
Methods of control—Continued.	
Cultural practices	10
Repellents	11
Maintenance of soil fertility	11
Cooperation as an important control measure	12

THE CORN ROOT-APHIS commits serious depredations on growing corn each year. It is very generally distributed throughout the United States east of the Rocky Mountains, but it is an especially destructive pest in the "corn belt" from Ohio to Iowa and Nebraska, including southern Wisconsin. Its abundance and destructiveness in these regions may be traced with reasonable certainty to the practice of growing two or more successive crops of corn on the same land, and this fact has a direct bearing on the practical control of the insect. It is injurious also to cotton in the South Atlantic States and to cultivated asters almost everywhere.

THE CORN ROOT-APHIS AND ITS INJURY.

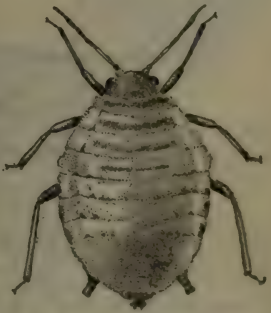

FIG. 1.—The corn root-aphis: Wingless female of the form that produces living young. Greatly enlarged. (Redrawn from Forbes.)

The corn root-aphis (fig. 1) is a small, soft-bodied insect not larger than a pin-head, almost spherical when full grown, and of a bluish-green color, more or less dusted with a fine whitish powder which makes it appear grayish-green. The aphids cluster on the corn roots (fig. 2) and suck the plant juices, this continual drain acting on the plant in somewhat the same way as a drought. The greatest and most noticeable injury occurs in spring before the plants have made any considerable growth. Infested plants are dwarfed and the leaves become brown or otherwise discolored. Although even the heavily infested plants seldom are killed outright, usually they do not make any appreciable growth. Infestations later in the season are less noticeable and indeed seldom are recognized because the plants as a rule are not injured outwardly. The extent of apparent damage varies with the season; conditions favoring the growth of corn sometimes enable the plants to make a fair development in spite of the insect, and an unfavorable season makes the injury unusually conspicuous.

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[1] *Aphis maidiradicis* Forbes.

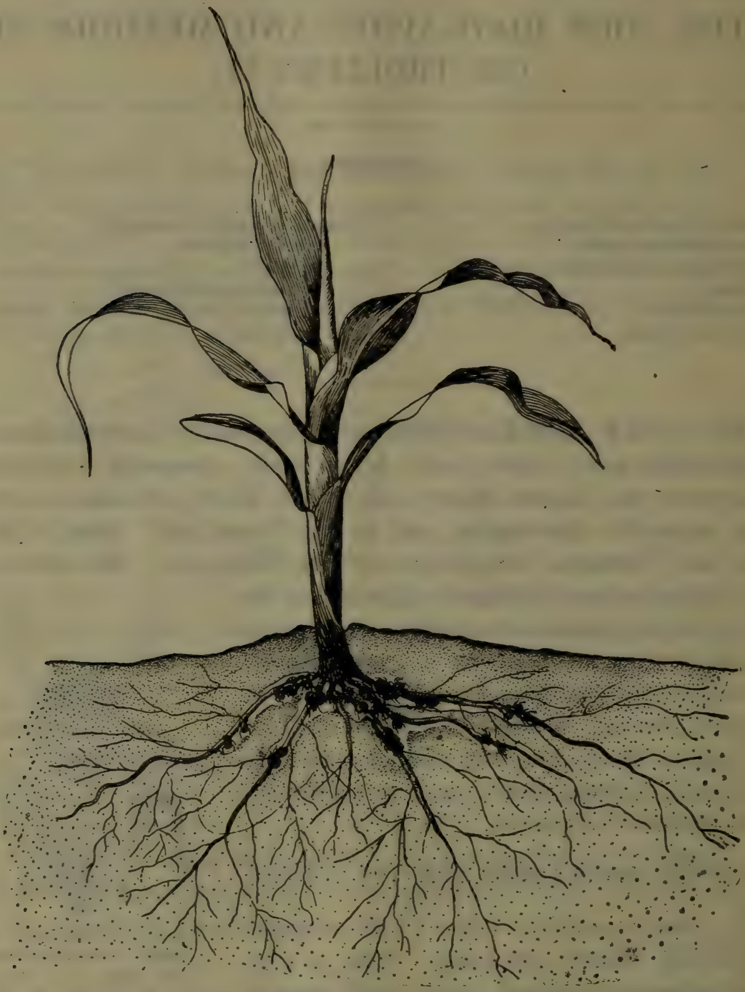

FIG. 2.—Young corn plant showing corn root-aphids feeding on the roots.

HOW TO RECOGNIZE ROOT-APHIS INJURY.

Injury by the corn root-aphis may be distinguished from that caused by other insects if the following points are observed: (1) Root aphids usually attack corn that is grown on cornland, although occasionally other ground may develop heavy infestations if it has harbored certain weeds and likewise the aphids. (2) Injury, resulting in a stunting of the plants and yellowing of the leaves, usually occurs in early summer, when the plants are from 6 to 18 inches high. (3) Ant hills and the common brown cornfield ants are to be found at or near corn plants attacked by root aphids. (4) Plants infested with root-aphids have a complete root system, but when uprooted the bluish-green aphids will be found thickly clustered on the roots and on the underside of the crown at the base of the roots.

SEASONAL HISTORY AND HABITS.

There are four distinct forms of the corn root-aphis. The true sexes—that is to say, the males and the egg-laying females (fig. 3)—occur only in the fall. These females lay the pale yellowish-green eggs which later turn to jet black. Ants take the aphid eggs to their nests and care for them during the winter months. In spring, and continuing throughout the summer, only winged and wingless females are to be found, and these give birth to living young. (See title-page illustration and fig. 1.)

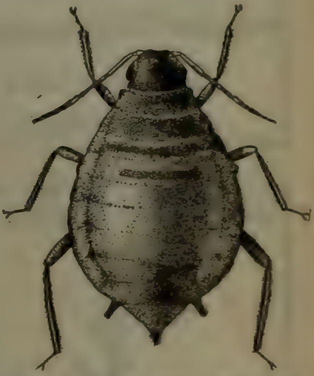

FIG. 3.—The corn root-aphis: Egg-laying female. Greatly enlarged. (Redrawn from Forbes.)

The seasonal history of this insect, which is graphically shown in figure 4, is as follows: The eggs, which are kept by the ants in their nests over winter, begin to hatch about the time smartweed seeds begin to germinate—usually the latter part of March or the first of April—and the young, frail aphids are transferred by the attentive ants to the roots of convenient weeds along which tunnels previously have been made. The aphis is able to live and reproduce on a large variety of weeds, but is most frequently to be found on such common field weeds as smartweed or knotweed,[1] crab grass,[2] purslane,[3] and foxtail or pigeon grass.[4] The young that hatch from eggs mature in about 15 days or longer and give birth to a second generation. Members of this and the succeeding generations until fall give birth to living young, which they produce without fertilization by a male. On an average about 16 or 17 generations occur from the date of hatching in the spring until fall, and the length of each generation varies according to the season, being longer in the spring and fall

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[1] *Polygonum* sp.

[2] *Digitaria sanguinalis.*

[3] *Portulaca oleracea.*

[4] *Setaria* sp.

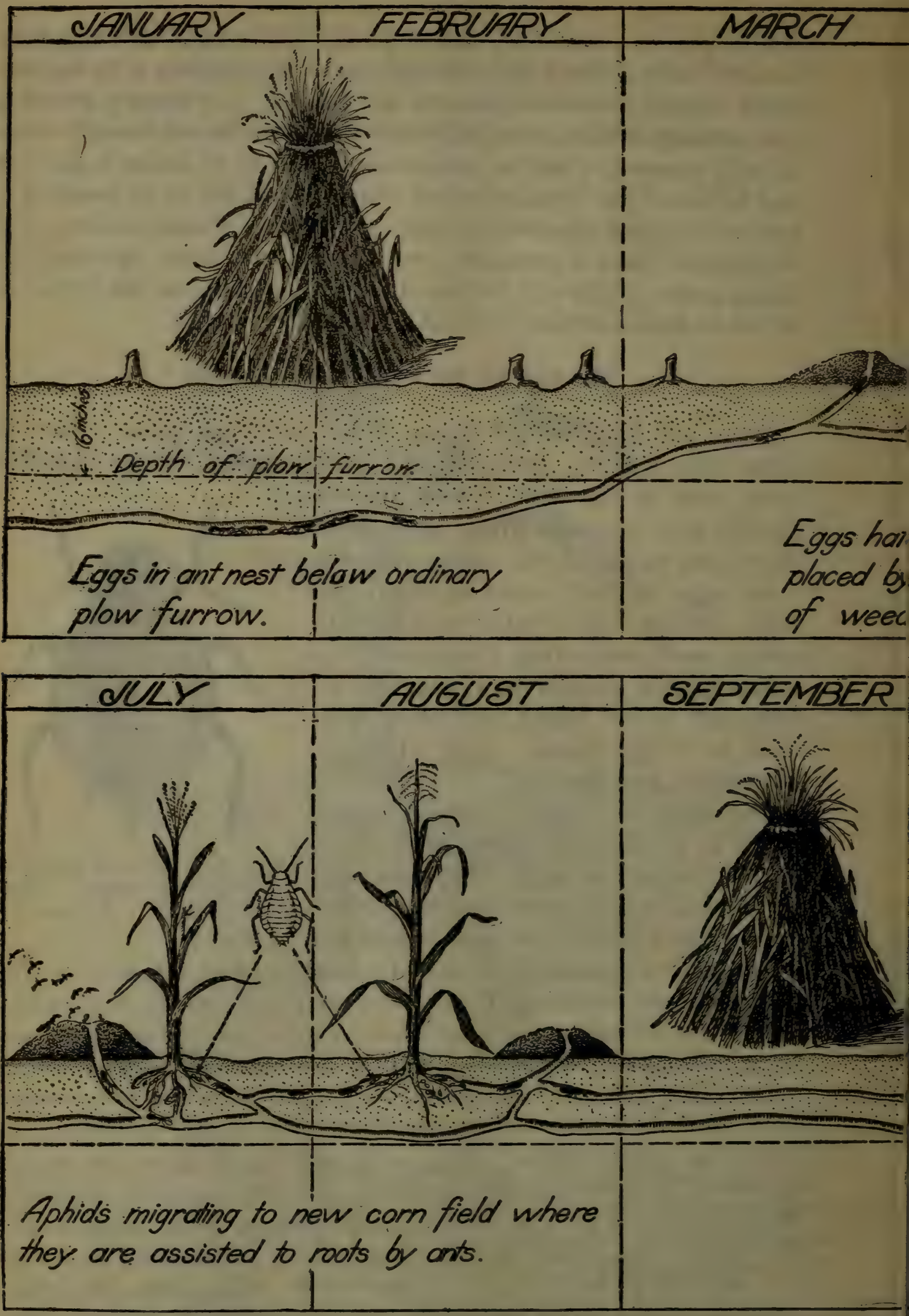
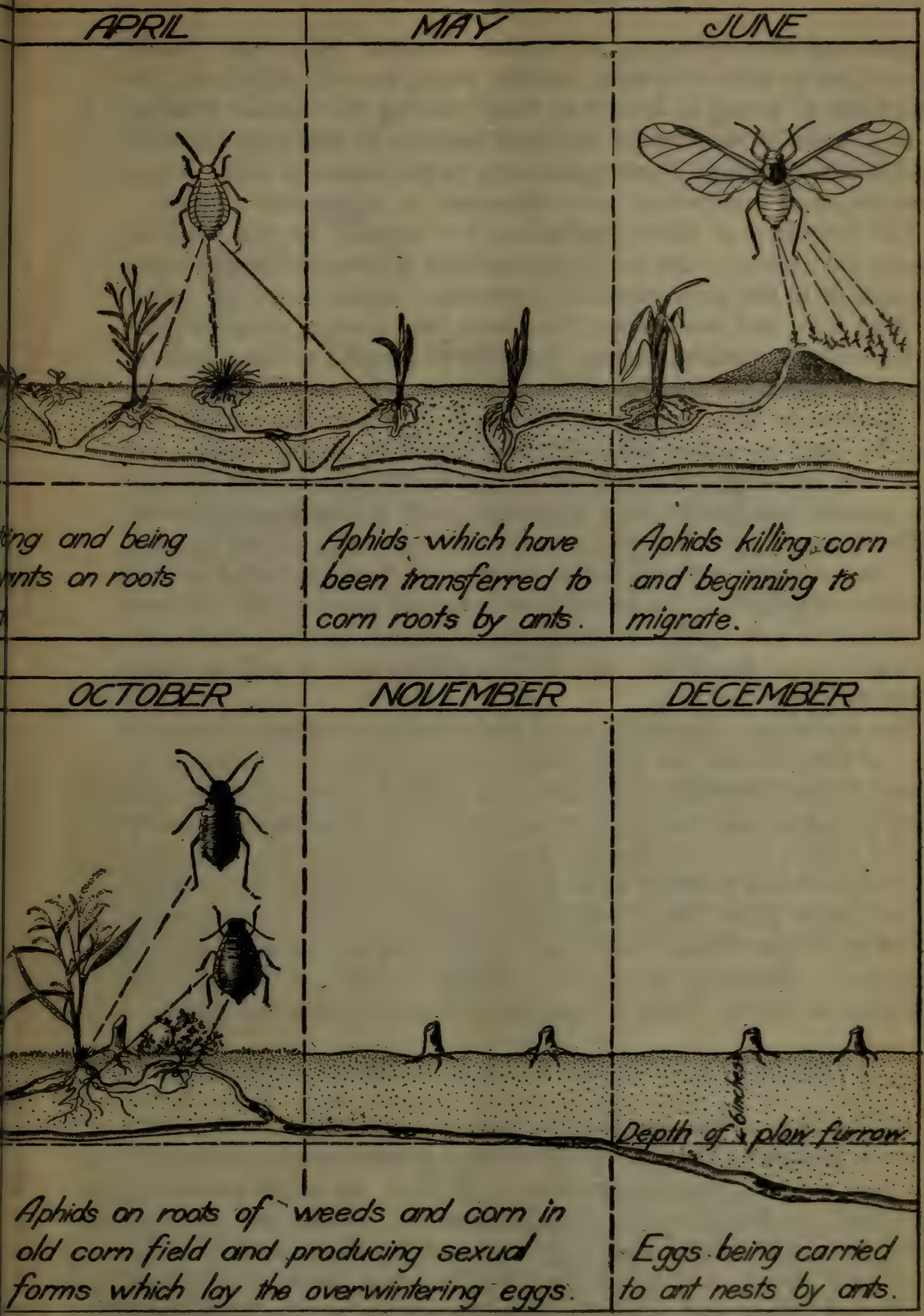

JANUARY
FEBRUARY
MARCH
6 inches
Depth of plow furrow
Eggs in ant nest below ordinary plow furrow.
Eggs ha
placed by
of wee
JULY
AUGUST
SEPTEMBER
Aphids migrating to new corn field where they are assisted to roots by ants.

FIG. 4.—Diagram showing history of the corn root-aphids and its relattions with the cornfield ant.
can n


APRIL
MAY
JUNE
ing and being
nts on roots
Aphids which have been transferred to corn roots by ants.
Aphids killing corn and beginning to migrate.
OCTOBER
NOVEMBER
DECEMBER
6 inches
Depth of plow furrow
Aphids on roots of weeds and corn in old corn field and producing sexual forms which lay the overwintering eggs.
Eggs being carried to ant nests by ants.

ote that during the winter the aphids are carried by the ants below the frost line, where the plow each them.

months and shorter during the summer months. Since each female gives birth to 40 or 50 young, and the young mature and themselves give birth to young in from 6 to 8 days during the summer months, it may be easily understood that they increase to enormous numbers and that the killing of one aphis early in the season is equal to the destruction of hundreds or even thousands in midsummer or later.

The first two or three generations live entirely on the roots of weeds, but as soon as the newly planted corn sprouts the ants transfer the aphids to the more succulent cornroots. Aphids are to be found on both corn and weed roots throughout the summer, wingless individuals always predominating; but after the second or third generation a considerable number of the aphids may be winged, and many of these make their exit from the ground through the ant tunnels and fly away to a new field. If they chance to alight near an ant hill, they are seized immediately by the watchful ants, carried into the burrow, and placed on a convenient root, giving rise to another infestation. Thus it happens occasionally that corn on new ground, but near heavily infested fields, becomes so badly infested in late summer, especially if the season is unfavorable to corn, that the crop is damaged noticeably—a consideration which *makes community cooperation an important measure in fighting this as well as many other field-crop pests.*

The males and the egg-laying females begin to appear about the first of October, and the eggs laid by these females are immediately stored by the attendant ants. As cold weather approaches the ants carry the eggs with their own young deeper into the soil, and usually by the middle of November, in the latitude of Illinois and Wisconsin, all will be found 8 inches or more below the surface, which is below the ordinary plow furrow—and this should be kept in mind when plowing is done in the fall in order that the ant colonies may be destroyed. Similarly in summer, during periods of drought, the ant colonies may be found 8, 10, or even 12 inches below the surface.

RELATION BETWEEN ANTS AND THE APHIDS.

As has been stated, the relation between ants and the corn root-aphis is intimate. Several species of ants are concerned, but by far the most common species occurring in fields is the small brown ant frequently spoken of as the "cornfield ant."[1] In the fall the ants carry the aphid eggs to their nests and care for them as they do for their own young, and in spring when the eggs hatch they tunnel along weed roots and place the helpless aphids on the host plant. (Fig. 5.) The aphids are cared for in the same way during the summer months; indeed, throughout life they are wholly dependent on the ant, which obtains in return for its work a sweetish fluid, the "predigested" sap of the corn or other plant, which is given off in considerable quantities by the aphids. Since the relationship between ants and aphids is so intimate, and since the aphids are entirely dependent on the ants, it is evident that *any method which will disturb, demoralize, or destroy the ant colonies will reduce the numbers of aphids*, and this fact will be explained further in the paragraphs dealing with the means of control.

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[1] *Lasius niger* L., var. *americanus* Emery.

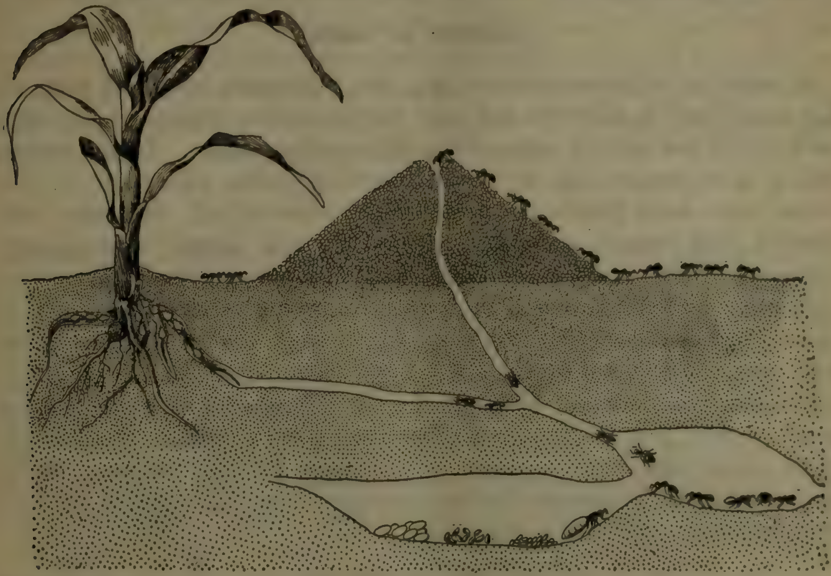

FIG. 5.—Diagram showing how ants foster the corn root-aphis. These aphids, which are cared for by the ants in their nests during the winter, are carried through tunnels to the corn plants and placed on the roots.

PAST HISTORY.

Previous to 1891 the corn root-aphis was generally supposed to be the subterranean form of the corn leaf-aphis,[1] which is everywhere present on corn, usually occurring beneath the leaf and ear sheath or the stalks of the unfolding tassel. As early as 1822 root-aphids, which were probably the corn root-aphids, were reported damaging corn in Pennsylvania, and in 1862 this species was definitely observed attacking corn roots and injuring the crop in Illinois. This pest has increased gradually in destructiveness until now it is recognized as one of the four or five most generally injurious insects affecting corn, for it occurs, with few exceptions, wherever this crop is grown in the United States.

---

[1] *Aphis maidis* Fitch.

METHODS OF CONTROL.

Most of the measures for the prevention or control of the corn root-aphis are methods which not only are effective in reducing or eradicating this and other insect pests, but constitute the more approved cultural practices and for this reason are doubly important.

ROTATION OF CROPS.

A rotation which avoids having two successive crops of corn on the same land is effective not only in preventing injury by the corn root-aphis, but also in controlling other serious pests. In the cotton belt it is important also to avoid following cotton with corn, or vice versa, since both plants are hosts of the same aphid. No other cultivated field crop is seriously affected by this insect; consequently corn may follow any other field crop with reasonable safety. Occasionally corn is damaged in spring following other crops, such as clover, but in these cases it will be found that smartweeds and other wild plants preferred by the aphis have occurred in the field in abundance the year before. Damage during late spring or summer may occur in corn following a crop other than corn or cotton, the infestations sometimes coming from neighboring heavily infested fields, but usually such damage occurs only in years unfavorable to corn growing and is of rare occurrence.

CULTURAL PRACTICES.

The most complete and effective means of controlling the corn root-aphis is thorough stirring of the soil previous to planting. The object of this procedure is to disturb the ant colonies and scatter and kill the aphids so as to permit the plants to make a substantial growth before the ant and aphid colonies can become reestablished, and in addition to prevent the growth of weeds upon which the aphids live, making it necessary for the ants to carry the surviving aphids to new fields. Infested fields which are to be replanted to corn should be plowed to a depth of 6½ or 7 inches in the spring, after March 15 in the latitude of central Indiana and Illinois; then they should have 3 or 4 diskings to a depth of 4 or 5 inches with a 16 or 20 inch disk, the number of cultivations and the intervals between them varying according to the length of the period between plowing and planting. When it is necessary to replant early injured corn the field should first be plowed deeply and thoroughly and then disked deeply 3 or 4 times at intervals of 2 or 3 days. Though these practices necessarily involve additional labor, they not only prevent injury by the corn root-aphis, but also put the field in a much better physical condition. Plowing in the fall before the ant colonies go below the plowline is sometimes as useful as spring plowing, but if warm weather follows the ants may reconstruct their nests so that replowing will be necessary in the spring. In either case the additional spring diskings are essential.

Early fall plowing followed by frequent deep diskings in fields damaged by the root-aphis that season is a good practice from the standpoint of community control, as well as for the personal benefit derived, for the plowing disturbs the ant colonies, kills many of the aphids, and destroys the weeds upon which they live, and the disking prevents the recolonization of ants and the growth of weeds. The result is a significant reduction in the number of aphid eggs—eggs being necessary to carry the insect over winter.

REPELLENTS.

Where it is impossible to practice one of the foregoing measures, an odorous substance offensive to the ants, which will prevent them from colonizing the aphids on the cornroots or will drive them from the treated field, may be used to advantage. This material does not destroy either the ants or the aphids, but tends to drive away the ants, the presence of which is essential to the life of the aphids. Oil of tansy, tincture of asafetida, oil of sassafras, anise oil, kerosene, and oil of lemon are useful for this purpose, these materials being mixed with a chemical fertilizer such as bone meal and applied by means of a planter equipped with a fertilizer attachment. They should not be applied directly on the seed, as such treatment may injure it, especially if the season be wet. Dilute one-fourth pound of oil of tansy with 2 quarts of alcohol and 1 quart of water, or 2 pints of asafetida with 1½ gallons of water, and add either of these substances, thus diluted, to 100 pounds of bone meal, this amount being sufficient for an acre.

MAINTENANCE OF SOIL FERTILITY.

The maintenance of soil fertility by the use of barnyard manure or a commercial fertilizer has been recommended frequently, but is of value only in assisting the plants to outgrow injury either by the corn root-aphis or by any other insect which gradually affects the plant. It does not limit the number of aphids or ants, directly or indirectly, and can scarcely be included properly as a remedial or preventive measure, for if the proper soil fertility were maintained by cultivation and crop rotation excessive artificial fertilization would seldom be necessary.

COOPERATION AS AN IMPORTANT CONTROL MEASURE.

One of the greatest difficulties in the control of insects injurious to field crops is lack of community cooperation, and injury by the corn root-aphis frequently may be traced directly to this cause. The individual farmer may protect his crop from early injury by the corn root-aphis by cultivation or rotation, *but if neighboring heavily infested fields are left untreated* and the insect is permitted to live and multiply undisturbed *the migrating winged aphids may infest fields previously free from them.* This is especially likely to be the case in years when the spring weather is of such a character that it permits the root aphis to multiply but serves to delay corn planting. It is therefore important that every farmer rotate his crops and cultivate his old cornfields so as to destroy the root-aphis and the attendant ant colonies, whether he plans to replant them to corn or not. If this be done by entire communities, this pest will soon be classed among the corn insects of minor importance or among those known to be only occasionally injurious.

PUBLICATIONS OF UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO INSECTS INJURIOUS TO CEREAL AND FORAGE CROPS, AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Common White Grubs. (Farmers' Bulletin 543.)
Larger Corn Stalk-borer. (Farmers' Bulletin 634.)
Chalcis-fly Alfalfa Seed. (Farmers' Bulletin 636.)
Grasshopper Problem and Alfalfa Culture. (Farmers' Buletin 637.)
Hessian Fly. (Farmers' Bulletin 640.)
Alfalfa Attacked by Clover-root Curculio. (Farmers' Bulletin 649.)
Chinch Bug. (Farmers' Bulletin 657.)
Wireworms Destructive to Cereal and Forage Crops. (Farmers' Bulletin 725.)
True Army Worm and its Control. (Farmers' Bulletin 731.)
Corn and Cotton Wireworm in its Relation to Cereal and Forage Crops, with Control Measures. (Farmers' Bulletin 733.)
Clover Leafhopper and its Control in entral States. (Farmers 'Bulletin 737.)
Cutworms and their Control in Corn and other Cereal Crops. (Farmers' Bulletin 739.)
Alfalfa Weevil and Methods of ontrolling It. (Farmers 'Bulletin 741.)
Grasshopper Control in Relation to Cereal and Forage Crops. (Farmers' Bulletin 747.)
Fall Army Worm, or "Grass Worm," and its Control. (Farmers' Bulletin 752.)
How to Detect Outbreaks of Insects and Save the Grain Crops. (Farmers' Bulletin 835.)
Bollworm or Corn Earworm. (Farmers' Bulletin 872.)
Rough-headed Corn Stalk-beetle in Southern States and its Control. (Farmers' Bulletin 875.)
Corn Root-aphids and Methods of Controlling It. (Farmers' Bulletin 891.)
Western Corn Rootworm. (Department Bulletin 8.)
Oat Aphis. (Department Bulletin 112.)
Alfalfa Caterpillar. (Department Bulletin 124.)
Wireworms Attacking Cereal and Forage Crops. (Department Bulletin 156.)
Sharp-headed Grain Leafhopper. (Department Bulletin 254.)
Desert Corn Flea-beetle. (Department Bulletin 436.)
New Mexico Range Caterpillar and its Control. (Department Bulletin 443.)
Two Destructive Texas Ants. (Entomology Circular 148.)

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SPRING OAT PRODUCTION

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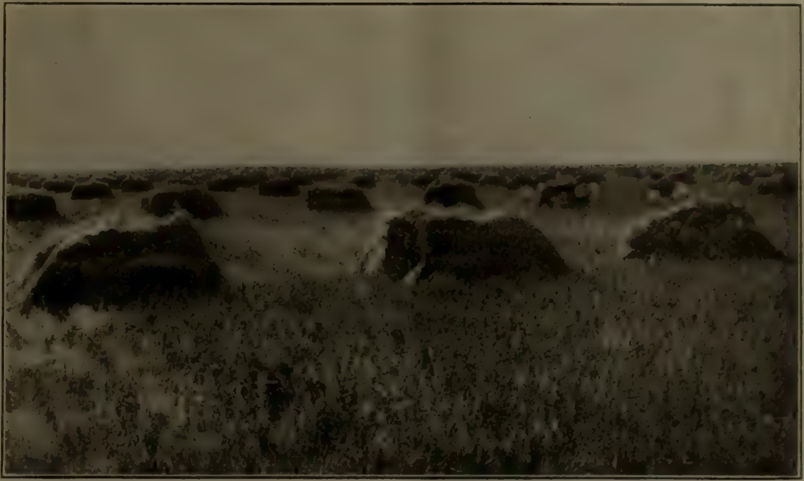

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FARMERS' BULLETIN 892

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C.   November, 1917   (Revision of No. 424, issued December 20, 1910)

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OATS rank next to corn and wheat in crop acreage and value in the United States. But, notwithstanding this, less attention has been given to the production of oats than to any other important grain, so that yields often have been unsatisfactory and the crop sometimes unprofitable.

The essentials for success in oat production are—

- Well-prepared land that is retentive of moisture and fairly fertile.
- Good seed of suitable varieties, thoroughly cleaned and graded and treated for smut.
- Early seeding with a grain drill.
- The harvesting of the crop at the proper time.
- Careful shocking and stacking so as to preserve the crop from injury by weathering.
- Clean thrashing.

Directions for making the growing of oats more generally profitable are given in the following pages.

SPRING OAT PRODUCTION.

CONTENTS.

	Page.		Page.
Importance of the oat crop	3	Sowing the seed	12
Soils adapted to the production of oats	4	Rate of seeding	13
Fertilizers and manures	5	Method of seeding	14
Oats in the rotation	6	Treatment after seeding	15
Common rotations that include oats	7	Cultivation	15
Growing in mixtures with other crops	7	Spraying to kill weeds	16
Clearing the land of weeds	8	Irrigation	17
Use as a nurse crop	8	Harvesting the crop	17
Use as a cover crop	9	Cutting	17
Preparation of the seed bed	9	Shocking	18
Preparation of the seed	11	Stacking	20
Treating the seed for smut	12	Thrashing	21

IMPORTANCE OF THE OAT CROP.

OATS constitute one of the most important grain crops in the North Temperate Zone. In the United States this crop is exceeded in acreage and value only by corn and wheat. It ranks far ahead of all other grain crops except wheat in Canada, and it is grown widely also in all the countries of northern Europe. The United States produces more oats than any other country in the world. The countries that rank next in importance in oat production in normal times are European Russia, Germany, Canada, France, and Austria-Hungary.

The average area annually devoted to oats in the United States in the five years from 1912 to 1916, inclusive, was 39,459,000 acres. This is approximately three-eighths of the acreage devoted to corn and three-fourths of the acreage devoted to wheat in the same years. The estimated average production of oats in these five years was 1,296,437,000 bushels, with an estimated farm value of $521,436,000. This latter figure is about three-tenths of the value of the corn crop and two-thirds of the value of the wheat crop in the same years. The accompanying map (fig. 1) shows that oats are grown most largely in the north-central United States. In fact, the 10 States of largest production lie wholly within this section. These States, in the order of their average production in the five years from 1912 to 1916, are Iowa, Illinois, Minnesota, North Dakota, Nebraska, Wisconsin, Ohio, Indiana, South Dakota, and Michigan. The production in these States ranges from more than 187,000,000 bushels, in Iowa, to nearly 51,000,000 bushels, in Michigan.

SOILS ADAPTED TO THE PRODUCTION OF OATS.

In the production of oats proper climatic and cultural conditions are of more importance than the character or even the fertility of the

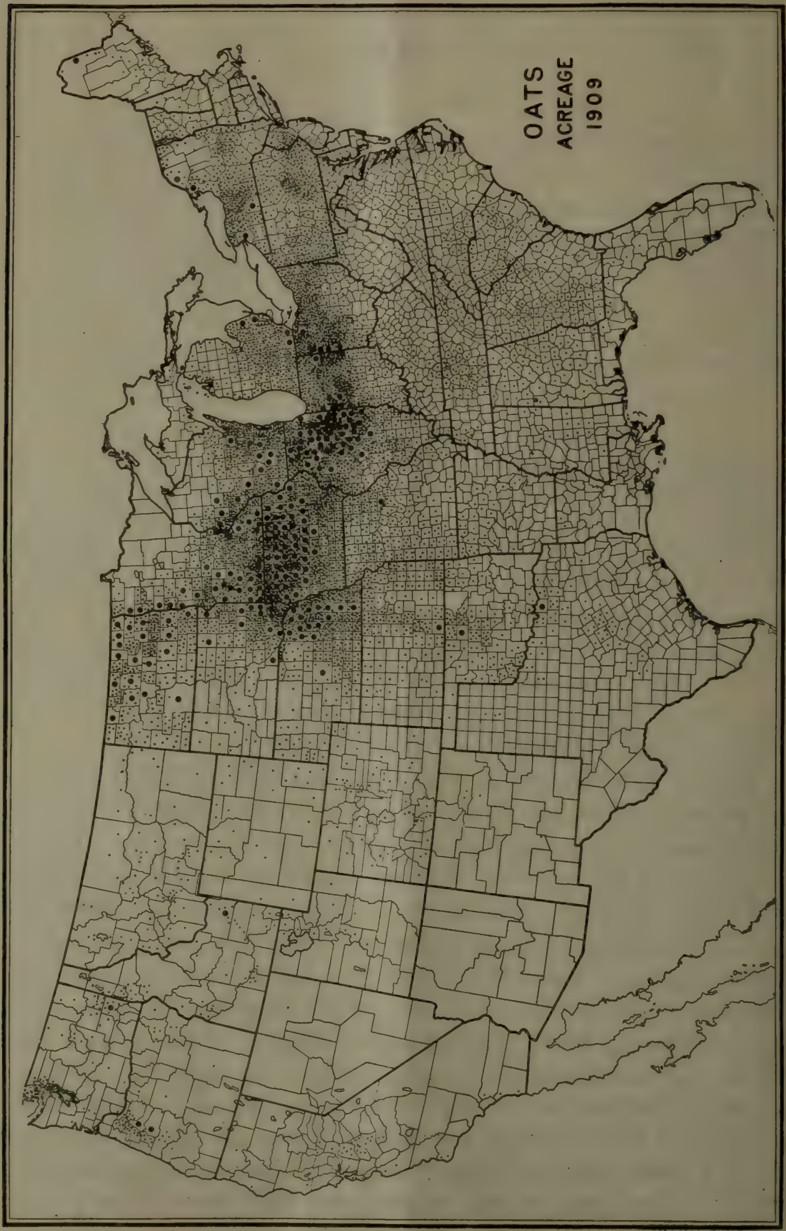

FIG. 1.—Map of the United States, showing the acreage in oats according to the census of 1909. Each heavy dot indicates 50,000 acres; each light dot indicates 5,000 acres.

soil. Owing to their greater water-holding capacity loam and clay soils usually produce better crops than sandy soils. Sandy land with plenty of plant food and a moderately stiff subsoil will grow good oats, but heavy, undrained clays are too wet and cold for the best growth of the crop. More water is required to produce a pound of dry matter in oats than in any other cereal; hence the necessity for growing this crop on land that naturally retains moisture or that is well filled with humus. On account of their liability to lodge, oats should not be grown on very rich soil or on low, undrained lands. Good drainage is essential also in the prevention of injury from plant diseases.

FERTILIZERS AND MANURES.

Though the oat crop is a vigorous feeder and will do better on poor soils than most other grain crops, the judicious use of fertilizers or manure is usually profitable. The fertilizer problem is made difficult, however, by the fact that on rich soil oats make a rank growth, which often results in lodging and in conditions favorable to rust and other diseases.

Unless the soil is very low in fertility the direct application of barnyard manure to the crop is seldom advisable. Much more satisfactory results usually can be obtained by applying the manure previous to growing some other crop in the rotation, such as corn. The oats then will get the benefit of a part of the manure and of the added humus in the soil, with less danger that a rank growth of straw will be made at the expense of grain production. On very poor soil a few loads of well-rotted manure may be applied some time previous to sowing oats. The manure should be spread as evenly as possible and should be well worked into the soil. The use of a small quantity of raw rock phosphate with the manure is usually advisable.

Of the three most important plant-food elements, nitrogen, phosphorus, and potash, phosphorus is the one most often present in insufficient quantities for the best production of oats. This is particularly true of some of the prairie soils in the upper Mississippi Valley, where a large portion of the oat crop is grown. Although phosphorus is usually the most important fertilizing element that can be added to the soil for the production of oats, small quantities of nitrogenous fertilizer often can be used to advantage. The oat crop makes most of its growth early in the season, when the weather is cool and before much of the nitrogen in the soil becomes available for plant food. For this reason the application of a small quantity of nitrogen in a readily available form will hasten its growth and result in materially increased yields. Potash usually can be applied more profitably to some other crop in the rotation, such as corn or wheat. This element is usually present in large quantities in clay soils, but is often a valuable addition to sandy or gravelly ones. The application of 10 to 20 pounds of actual potash to the acre annually is usually sufficient on loam and clay soils, but on soils that are known to be rich in this material its use is unnecessary.

A good fertilizer for oats on the heavier loam and clay soils is one containing 50 pounds of nitrate of soda and 150 pounds of acid phosphate, applied at the rate of 200 pounds to the acre. On sandy and gravelly soils the addition of 20 to 40 pounds of muriate of potash to this combination is usually beneficial. The exact quantity to be applied and the proportion of the different fertilizing elements depend largely on the nature and the fertility of the soil and the price of the fertilizers. The straw of grain crops may be strengthened by the use of fertilizers containing potash and phosphorus, and in this way lodging sometimes may be prevented. Lodging in the principal oat-growing sections, however, is due oftener to the blowing over of the whole plant by heavy winds when the ground is soft from excessive rains than to actual weakness of the straw.

When the crop is desired for forage rather than for grain, the use of barnyard manure or fertilizers rich in nitrogen is often advisable, as nitrogenous fertilizers induce the rank growth necessary for the production of large yields of forage.

Liming alone is not likely to increase the yield of oats. On very sour soils or when used in connection with the plowing under of green-manure crops or stable manure lime may have a beneficial effect. Although the application of lime or fertilizers to oats may not be directly profitable, the increased yields from succeeding crops may often more than make up the deficiency. This is particularly true when clover or a grass crop is to follow the oats.

OATS IN THE ROTATION.

Among the factors that determine the place of the oat crop in the rotation are the effect of the preceding crop on the growth of the oats and the effect of the oats on the following crop. Ordinarily oats are not grown after a grass or clover crop, a cultivated crop being used to subdue the sod. In sections where new land is being brought under cultivation oats usually are grown on "old land," wheat and flax being the crops that ordinarily are grown on sod land if a cultivated crop such as corn or one of the sorghums is not used. When grown on sod land, especially where the sod consists wholly or in part of clover or alfalfa, oats are inclined to grow rank and lodge. Where there is less trouble from lodging, as in some of the irrigated sections of the West, oats may follow clover or alfalfa.

Oats are less influenced by the effect of the preceding crop than are most other grains, so that where wheat, barley, and oats are the main crops, the rotation, if one is practiced, is arranged to suit the other grains rather than the oats. Where corn or some other cultivated crop is grown, oats usually follow the cultivated crop and are followed by grass or clover, which usually are sown with the oats.

COMMON ROTATIONS THAT INCLUDE OATS.

A common rotation in Iowa, Illinois, and other corn-belt States consists of corn, oats, and grass or clover. Usually this is a 5-year rotation, two crops of corn being grown in succession, followed by oats, with grass and clover seeded with the oats; the grass is allowed to remain for two years, either as meadow or pasture, and is then plowed up for corn. Sometimes the rotation is shortened to four years, either two years of corn and one each of oats and grass or one year each of corn and oats and two years of grass. The first of these two rotations is the common one where clover alone is used as the hay crop. Where winter wheat can be grown, it is customary to use it as a nurse crop for grass or clover. The common rotation where both oats and winter wheat are grown is corn, oats, winter wheat, and grass or clover for one or more years. In Maine and in some of the other potato-growing sections a common rotation consists of potatoes, oats, and clover, each one year. In the spring-wheat section, if corn is grown the common rotation is corn, wheat, oats, and grass. In some portions of the spring-wheat belt no rotation is practiced, particularly if corn and grass are not included among the staple crops. In the South oats occupy so small a portion of the cultivated area that they do not figure commonly in the rotation. In this section a good rotation that includes oats consists of corn, with cowpeas sown between the rows; oats, followed by cowpeas; and cotton. In the irrigated sections oats sometimes are grown in rotation with clover or alfalfa.

GROWING IN MIXTURES WITH OTHER CROPS.

Oats are sometimes grown in combination with other crops for the production of either hay or grain. In the United States the most common combination of this kind is oats and Canada field peas. Rape is often sown with oats, to be used as pasture for hogs or sheep after the oats are harvested. In Canada, barley and oats are commonly grown together, and other grains are sometimes included in the mixture.

Where peas are grown with oats the crop is used as pasture or cut for feeding green or for hay. A common rate of seeding is 1 bushel of peas and 1½ bushels of oats to the acre, though an equal mixture is often used, sowing from 2 to 3 bushels to the acre. Where vetch does well it is sometimes substituted for the peas. A common proportion is 2 parts of vetch to 1 of oats. The combination of a legume with oats for pasture and soiling purposes increases both the yield and the feeding value of the crop, while the legume adds nitrogen to the soil.

Oats and barley grown together often yield more than either sown alone. This combination is a very popular one in Ontario, though it is not common in the United States. It is necessary to use an early variety of oats so that the two crops will ripen together. These crop mixtures are usually used for feeding on the farms where they are grown, as they are not readily marketable except as feed grain. The best yield is generally obtained from sowing 1 bushel each of oats and barley. Emmer, spring wheat, and other grains may also be grown with oats, but none of the combinations yield as well as the barley-oat mixture.

A small quantity of rape seed, 1 to 2 pounds, is often sown with oats. It is good practice, however, to sow the rape two or three weeks after the oats are sown, covering the seed by harrowing lightly. If sown at the same time as the oats it makes so much growth that it interferes with the harvesting of the oats. If the oats are cut with a rather high stubble, if the season is favorable the rape will at once start into vigorous growth and make excellent pasture for sheep and hogs. Sheep, in particular, do well on this pasture, as they glean any grain that may have been left by the binder. Rape sown in this way may also be cut for feeding green, or when sown with the oats or with oats and peas the entire crop may be cut green, thus furnishing a large yield of succulent feed.

CLEARING THE LAND OF WEEDS.

As oats start into growth early in the season and soon make a dense shade, they are one of the best crops for clearing land of weeds. For this purpose they should be sown rather more thickly than on land that is free from weeds. The crop may be cut for grain or for hay, as desired, but it should be harvested before many of the weeds that grow with it mature their seed. The land then may be pastured to keep down the later growth, or the weeds that develop after the oats are harvested may be cut with the mower or plowed under before they mature seed. If the field is plowed it should be disked or harrowed occasionally to destroy any weeds that start into growth. If fall grain is sown or if the land is used for a cultivated crop the next season, it will be practically free from annual weeds by the end of the second year.

USE AS A NURSE CROP.

Oats are used very commonly as a nurse crop for clover and grass and sometimes, in the irrigated sections, for alfalfa. Although not ideal for the purpose, as the foliage is rather too dense and the crop draws too heavily on the soil moisture, good results usually are obtained. The sudden change from dense shade to full exposure to the sun when the oats are harvested sometimes injures the young clover and grass plants. In dry seasons oats may take the moisture from the soil so completely as to check severely the growth of crops sown with them. Either barley or wheat is more suitable for use as a nurse crop, making less shade and requiring less water. Where oats are used the selection of small, early varieties is advisable, because they grow less rank and take less water from the soil than the later, larger growing varieties. They also mature early enough to harvest before the hot weather, which is likely to injure the young grass. Less seed should be used where oats are sown as a nurse crop than when sown for other purposes. Drilling is preferable to broadcast seeding, as the space between the rows admits light and air to the grass and clover plants.

USE AS A COVER CROP.

Oats are used to some extent as a cover crop in orchards in the Northern States. They draw rather heavily on the soil moisture, thus checking the growth of the trees and causing the young wood to mature fully before cold weather. Oats make a dense cover and thus protect the soil from intense summer heat. They also furnish considerable winter protection, though the plants make a close mat on the ground after heavy frosts and do not hold snow as well as some other cover crops. The use of peas or vetch with the oats increases the value of the cover, as these crops add nitrogen as well as humus to the soil. The proper dates and rates of seeding for cover crops depend largely on the locality and the practice of the particular fruit grower who uses them.

PREPARATION OF THE SEED BED.

Less attention ordinarily is given to the preparation of the seed bed for oats than that for any other field crop. In the corn belt, where oats commonly follow corn, the seed is often sown broadcast without previous preparation of the land. It is then covered by disking and harrowing. Much better results are obtained, however, by disking the land before seeding, whether the seed is sown broadcast or is drilled. A good seed bed usually can not be prepared with fewer than two diskings and at least one harrowing. If the oats are to be sown on cornland on which the stalks are still standing, it is good practice to break the stalks before disking. This can be done readily, especially on a frosty morning, by dragging a heavy pole or iron rail broadside across the field. The stalks then can be cut with a disk harrow much better than if left standing. If the disks of the disk harrow are sharp, they will cut the stalks into short pieces, which soon decay. It is never advisable to rake and burn stalks and other trash on cornfields that are to be sown to oats unless the quantity is so great that it can not possibly be covered by disking. This humus-making material should not be destroyed but should be worked into the soil. A disk harrow in operation on cornstalk land is shown in figure 2.

Oats always should be sown as early in the spring as the land can be worked, but proper preparation should not be sacrificed to gain a little time in getting the seed into the ground. Oats do best when sown in a rather firm seed bed, with 2 to 3 inches of loose, mellow soil on the surface. This can be obtained best on cornstalk land by breaking the stalks, double disking either by lapping half or cross disking, and thorough harrowing with a spike-tooth harrow. Lapping half with a disk harrow leaves the surface more nearly even than when the field is cross disked. The disks should be set to run 3 or 4 inches deep. After the seed bed is in good condition the seed should be sown and the field again harrowed. A spike-tooth harrow in use in completing the preparation of an excellent seed bed for oats is shown in figure 3.

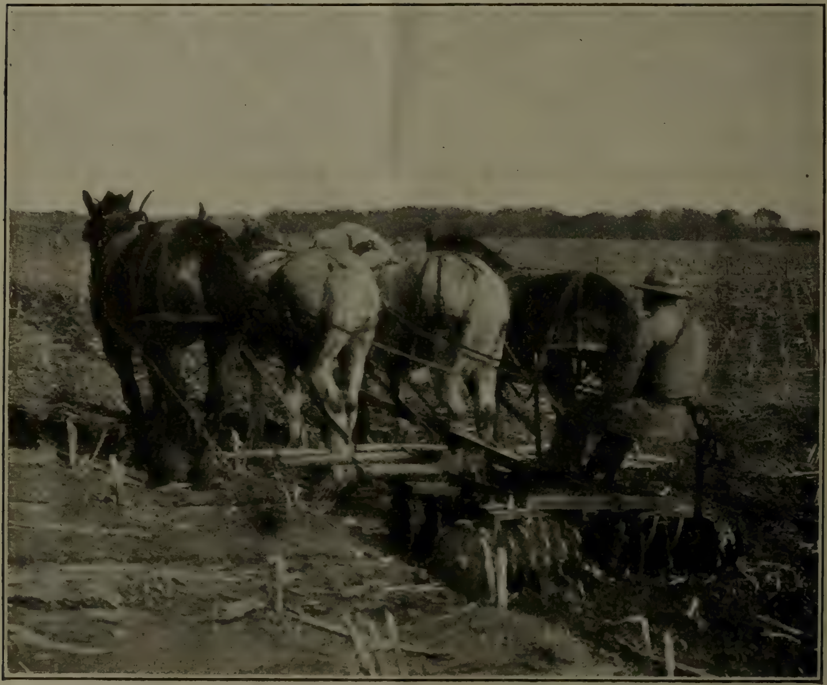

FIG. 2.—Preparing a seed bed for oats on cornland by the use of a disk harrow.

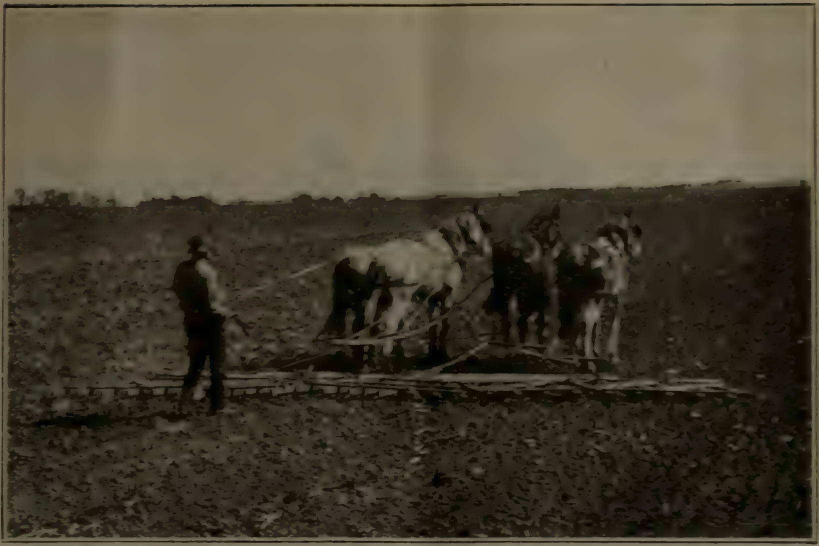

FIG. 3.—Completing the preparation of a good seed bed for oats on cornland with a spike-tooth or smoothing harrow.

The land seldom is plowed for oats that follow a cultivated crop. Spring plowing usually is not profitable, as there is little time to allow the subsurface to become compact and the land is rarely in proper condition to plow before the oats should be sown. Soils that are not likely to blow or run together sometimes can be plowed in the fall to advantage, particularly if grass seed is to be sown with the oats. A fine, smooth, mellow seed bed thus can be prepared. Fall-plowed land should be double-disked about 3 inches deep before seeding and harrowed both before and after seeding. A disk harrow in operation on fall-plowed stubble land is shown in figure 4.

PREPARATION OF THE SEED.

Seed oats should be screened and graded carefully before sowing. This work ordinarily is done with a fanning mill, the light oats and some of the trash being taken out by a current of air, while the small oats and most of the weed seeds are screened out. Ordinarily one-third or one-fourth of the oats should be taken out, but if the seed is very light a much larger proportion should be removed by the fans. Many of the small, light oats will not germinate at all, while others produce weak plants, which materially reduce the yield. Screening also greatly reduces the proportion of weed seed, thus preventing the spread of weeds and further favoring the growth of the oat crop. Figure 5 shows an uncleaned sample of oats unsuitable for seed and a cleaned sample with the weed seeds, trash, and light oats removed.

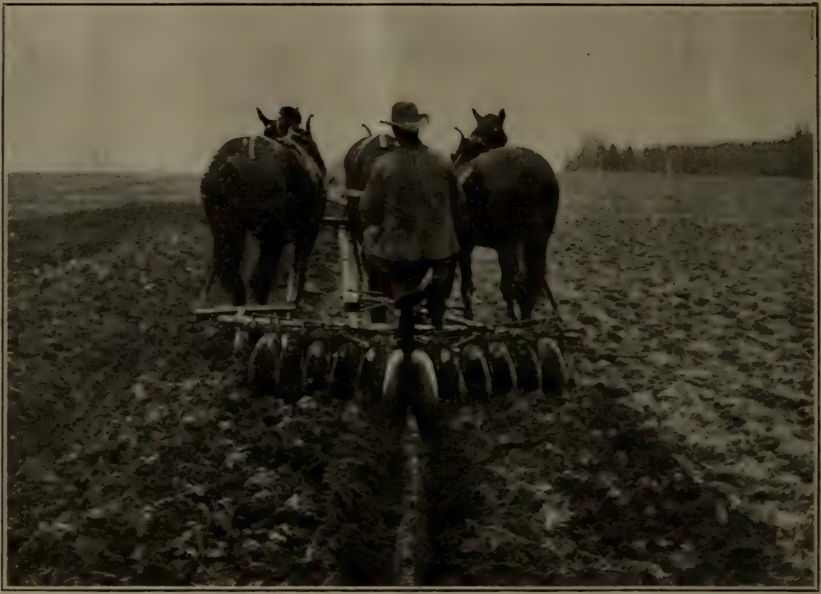

FIG. 4.—Disking fall-plowed stubble land to prepare a seed bed for spring-planted crops.

TREATING THE SEED FOR SMUT.

The yield of grain and the quality of the crop also can be materially increased by treating the seed for smut. An easy and effective method of treatment is to sprinkle the seed oats with a solution made by adding 1 pound of formaldehyde to 40 gallons of water.[1] After the smut balls and trash have been removed by fanning, the seed should be spread on a clean floor, thoroughly sprinkled, and shoveled over until all of the grain is well moistened. It should then be covered with blankets or canvas and allowed to stand for several hours. It can then be sown at once or spread out in a clean place to dry. The seed will run through the drill much more readily if dried before seeding. The rate of seeding should be somewhat increased, to allow for the swelling of the seed. The treated seed should not be put into sacks, bins, or machinery unless the smut spores in them have been killed by treatment with the formaldehyde solution.

SOWING THE SEED.

One of the greatest essentials in growing oats is to get the seed into the ground early. This crop grows best in cool climates and in cool weather and often is injured materially by a few hot days when it is near maturity. Frosts or even hard freezes after the seed is sown seldom injure it, so that, as a rule, oats should be sown just as soon as the ground is in condition to work in the spring.

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[1] A full description of this and other methods of smut treatment is contained in Farmers' Bulletin 507, entitled "The smuts of wheat, oats, barley, and corn." This bulletin may be obtained free from the Division of Publications, U. S. Department of Agriculture.

The exact date of seeding naturally depends on the locality and the season. In the South the seeding of spring oats begins in the latter part of January or early in February, and in the Northern States it is not completed until May. The best date in Kansas, Missouri, southern Illinois, and Kentucky ranges from March 10 to March 25. For Pennsylvania, Ohio, Indiana, central and northern Illinois, Iowa, and Nebraska the best date is usually from March 25 to April 15, though a somewhat later date sometimes may be necessary. In the Northern States seeding during the latter half of April is advisable whenever possible, though in favorable seasons seeding before the middle of the month often can be done to advantage, and in unfavorable ones in the extreme North May seeding is necessary. In the Rocky Mountain and Pacific States seeding is governed so largely by local conditions that no definite dates can be given. In some districts, owing to the distribution of the rainfall, late seeding may be more uniformly successful than early seeding.

RATE OF SEEDING.

The rate of seeding depends on the locality, the condition and fertility of the soil, the method of seeding, and the size of the seed.

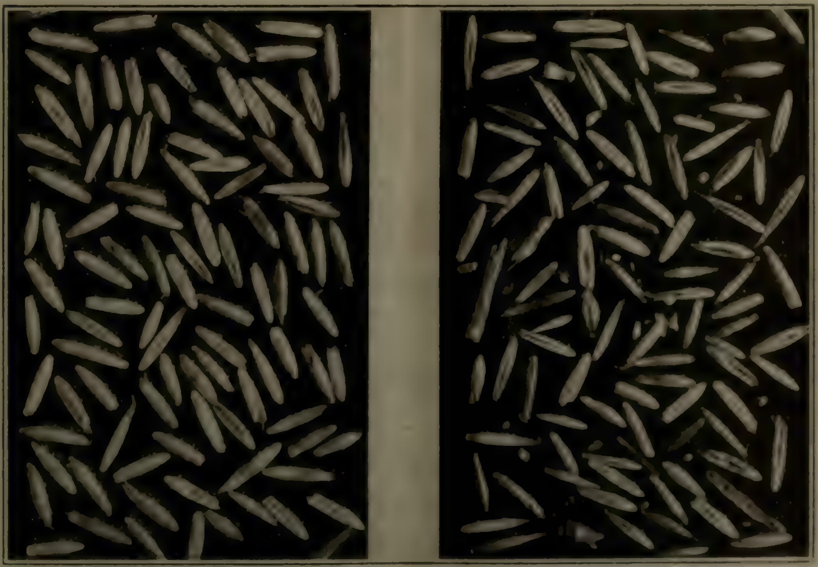

FIG. 5.—Sample of oats containing small kernels, trash, and weed seeds (right), and one of seed oats from the same lot suitable for sowing, the trash, weed seeds, and small, immature kernels having been removed.

As with other crops, less seed is required in dry than in humid sections. Fertile soils require less seed than poor ones, as on rich land the plants grow larger and tiller more. More seed should be sown on weedy land or on land not well prepared than on clean, mellow soil. Drilling requires less seed than sowing broadcast. More bushels of large-kerneled than of small-kerneled oats should be sown on an acre. The large-kerneled varieties usually grow ranker and the plants occupy more space than the small-kerneled ones, but the difference in the size of the plants does not equalize the difference in the thickness of the stand caused by the greater number of plants produced from a bushel of small-kerneled oats.

In general, the rate of seeding in the upper Mississippi Valley ranges from 8 to 12 pecks to the acre, but in the drier sections of the West this rate is reduced by half. In the irrigated sections 6 to 8 pecks is the common rate. Where the usual rate in broadcast seeding is 12 pecks, 10 pecks will be sufficient if the seed is drilled.

Many experiments have been conducted to determine the best rate of seeding in different localities. These experiments show, in general, that tillering depends very largely on the thickness of the stand and that within certain limits the plants on thinly seeded plats will tiller sufficiently to bring the number of stalks up to that produced by thick seeding. Thus, there is often little difference in the yield of grain or straw harvested from widely differing rates of seeding.

METHOD OF SEEDING.

The two common methods of seeding are drilling and sowing broadcast. The use of a drill has increased greatly in recent years, though some of the crop still is sown broadcast and a disk or smoothing harrow used to cover the seed. The ideal method of seeding is one that distributes the seed evenly in the ground and covers it to a uniform depth. Neither of these results is obtained in broadcast seeding and both are possible by drilling. Less seed is necessary, the depth of covering is more nearly uniform, the seed germinates more evenly, and its growth throughout the season is better when the seed is drilled. Clover and grass sown with the oats usually grow better in drilled than in broadcast grain. A grain drill in operation on well-prepared land is shown in figure 6.

The depth to which the seed should be covered depends on the nature of the soil and the quantity of moisture it contains. In moist soil shallow seeding is best, covering the seed to a depth of 1 to 1½ inches. In dry soils or in loose, sandy loams, which lose their moisture readily, deeper seeding is advisable. In the semiarid section the seed ordinarily should be sown deep enough to get it into soil with sufficient moisture for germination. This may require sowing as much as 3 inches deep. If sown broadcast, the seed should

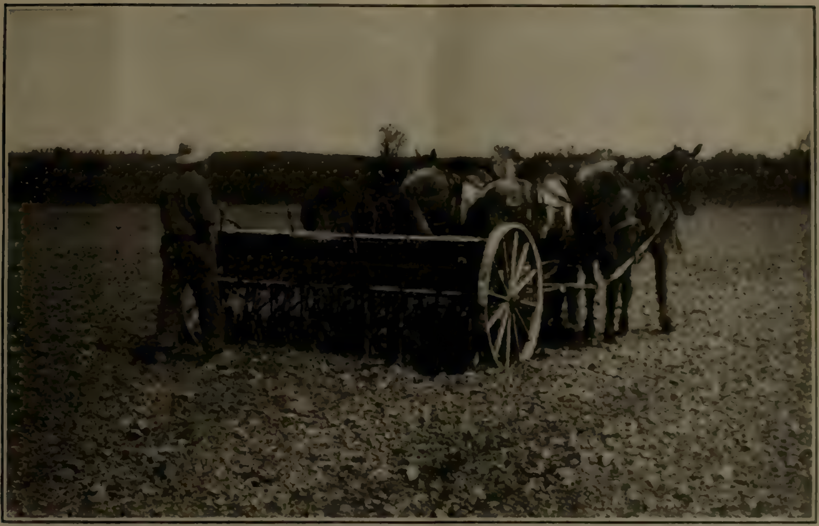

Fig. 6.—Sowing oats with a grain drill on well-prepared land.

be covered by shallow disking or thorough harrowing. Usually, if the field has been double-disked or harrowed and is in good condition before seeding, harrowing twice will cover the seed sufficiently. At best, however, in broadcast seeding it is impossible to cover all the seed to the same depth; some of it is left on the surface and does not germinate at all, while some is covered so deep that its germination is delayed greatly.

TREATMENT AFTER SEEDING.

The yield of oats sometimes can be increased by treatment given after the crop is sown. The most important methods for thus increasing the yield include cultivation, spraying to kill weeds, and irrigation.

CULTIVATION.

On loose, sandy soil or on spring-plowed land germination and early growth sometimes can be hastened by rolling after seeding. On soils that are inclined to pack and bake, the roller should be used with caution, as its use is likely to increase this tendency. A light harrowing after rolling, to break the crust and hold the soil moisture, is beneficial.

The cultivation of small grain with a harrow or weeder seldom is practiced; but experiments indicate that it may be worth while, particularly in regions of light rainfall. If a harrow is used, the teeth should be slanted backward, so as not to pull out the young grain. Cultivation with a harrow is sometimes of advantage on very weedy ground, even where the rainfall is ample, as the weeds are killed readily when small. The harrow should be used, however, only on dry fields and only after the young grain is well rooted.

Large weeds that develop with the crop, if not too numerous, often can be removed by pulling or cutting, without much injury to the oats. The gain from preventing the spread of the weeds more than repays the necessary loss from trampling in removing them. This should be slight, particularly in drilled grain.

SPRAYING TO KILL WEEDS.[1]

Several of the common annual weeds of grain fields can be kept in check by spraying with a chemical solution. The chemical kills the weeds without seriously injuring the grain or the young grass seeding. Common wild mustard is the weed most commonly controlled by spraying, but ragweed, kinghead, corn cockle, pigweed, smartweed, Canada fleabane (horseweed), marsh elder, cocklebur, wormseed mustard, and green tansy mustard also can be destroyed. Wild radish, chickweed, peppergrass, ball mustard, and black mustard are more resistant to the spray, but can be killed by repeating the treatment. Pennycress (Frenchweed), false flax, hare's-ear mustard, tumbling mustard, Indian mustard, and wintercress are not affected seriously by the spray, nor are any of the perennial weeds, such as Canada thistle, wild morning-glory (bindweed), curled dock, and perennial sow thistle. Grasses are not injured, but clover and alfalfa are damaged seriously and should not be sprayed.

Iron sulphate (copperas or green vitriol) is the most convenient and reliable material, using 100 pounds of granulated (sugar form) iron sulphate to 50 gallons of water. Copper sulphate (blue vitriol or bluestone) is also effective, using 12 to 15 pounds to 50 gallons of water. Common salt is serviceable, if the others can not be obtained, using one-third barrel (90 to 100 pounds) to 50 gallons of water. The usual application is 50 to 60 gallons of the solution per acre.

The time of spraying is very important. The work should be done early in the season, while the weeds are small and before they have formed flower buds. In the northern United States this will be usually from May 25 to June 10. If sprayed after the flower buds are formed, the weeds are almost sure to produce more or less seed.

Spraying should be done, if possible, on a quiet, sultry day when rain is not probable for at least 18 hours. On a very hot, dry day the spray dries off too rapidly. Spraying has not proved successful in the upper Great Plains area, owing to the prevailing high winds and low relative humidity.

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[1] This section on spraying to kill weeds has been prepared by Mr. L. W. Kephart, scientific assistant in weed investigations. Detailed directions for this work can be obtained upon application to the Office of Forage-Crop Investigations, U. S. Department of Agriculture.

Small patches of weeds can be sprayed with a bucket pump or knapsack sprayer, but for larger areas a good hand-operated force pump or a 2-wheel traction sprayer is necessary. Such an outfit with a suitable arrangement of nozzles for spraying a solid strip will cover 10 to 20 acres a day. The cost of spraying varies from $1.25 to $1.75 an acre, depending largely upon the convenience of the water supply. Usually the increase in the oat crop due to eliminating the weeds will at least cover the cost of spraying.

IRRIGATION.[1]

Oats require rather more water for their best growth than wheat, though varieties of both grains differ widely in this respect. The irrigation of oats is practiced to a considerable extent in the Rocky Mountain and North Pacific States, particularly in Montana, Idaho, Utah, and Colorado. Ordinarily water is applied in two irrigations, though three or four sometimes are given. When two applications are made, the first is usually just before heading begins; the second and much heavier one is applied when the grain begins to fill. Opinions vary greatly as to the supply of water needed for this crop, though 15 to 20 inches is probably the most profitable quantity. Where plenty of water is available much more is applied ordinarily. The quantity of water to be used depends upon the nature of the soil. The danger, especially where water is plentiful, is in overirrigation.

HARVESTING THE CROP.

CUTTING.

Oats usually are cut with a grain binder, though in the drier sections the header or the combined harvester and thrasher is used occasionally. A binder in operation in a field of oats in North Dakota is shown in figure 7. When the straw is very short, due to drought, or when the crop is badly lodged, cutting with a mower may be necessary. The grain may then be raked and put into cocks, which should be built so as to shed rain. The proper time to cut oats is when they are in the hard dough stage. Cut before this time the grain is not well filled, it shrivels in curing, and is light in weight. If allowed to become fully ripe before cutting, a considerable part of the crop shatters out and is lost in harvesting. The

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[1] Farmers' Bulletin 863, entitled "Irrigation of grain," describes the methods of applying water to grain crops and gives other details of irrigation practice. Copies may be obtained free from the Division of Publications, U. S. Department of Agriculture.

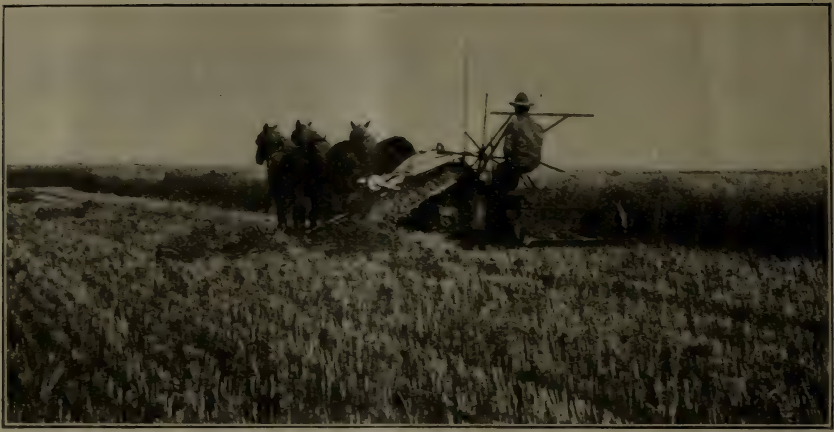

FIG. 7.—Grain binder at work in an oat field in North Dakota.

danger of damage from storms also is increased. When a large acreage is to be harvested it is advisable to begin cutting soon after the grain passes out of the milk stage, as otherwise a considerable part of the crop is likely to become too ripe before it can be cut.

SHOCKING.

If the grain is ripe or in the hard dough stage when cut, it may be placed at once in round shocks, which should be capped to prevent damage from rain and dew. The best quality of grain can be obtained under these conditions. If the grain is green or if the bundles contain many weeds, they should be allowed to cure for a few hours before shocking, and then should be placed in long shocks, which may or may not be capped. Long shocks allow the sun and air to penetrate much more readily than round ones and are to be preferred when the grain is cut green or when conditions for curing are not favorable. If long shocks are capped properly, they protect the grain from weathering quite as well as round shocks. Grain that is wet from dew or rain should be allowed to dry before it is shocked. In sections where strong winds prevail during the harvest season capping is not advisable, as the caps blow off and the cap sheaves may be injured by contact with the ground.

A good round shock may be built by first setting up two bundles with the flat sides facing, the heads together, and the butts a few inches apart. These bundles should be jammed down hard into the stubble, so that they will stand firmly. Then set another bundle at each end of this pair, so that there will be four in a row. Next set one in the middle of each side. This leaves at each of the four corners a space in which a bundle should be placed. There are now 10 bundles in the shock, which is about the right number. If the grain is very dry, a few more bundles may be set around the shock where they seem to fit best. When the desired number of bundles is set up, the shock should be capped. One or two bundles may be used in capping, depending on the length of the straw and the dryness of the grain. One cap allows better circulation of air through the shock, while two caps afford greater protection from rain. The cap bundle is broken by supporting it with the butts on one knee and with one forearm and hand under it at the band, while the straw at each side is broken over just above the band with the other hand. The straw of about half the bundle is broken to the right with the right hand; then the hands are reversed and the remainder of the bundle is broken to the left with the left hand. If one cap is used, it always should be placed with the heads toward the direction of the prevailing winds. If two are used, they may be placed at right angles to each other. A well-built, round shock is shown in figure 8.

Long shocks may be built by setting up two bundles with the flat sides facing, the tops together, and the butts several inches apart to allow circulation of air between them. The next pair of bundles should be set up alongside the first in the same way, with the tops leaning slightly toward the first pair. The shock is completed by setting another pair at each end and then placing single bundles with the flat sides in the opening between each end pair. If desired, more

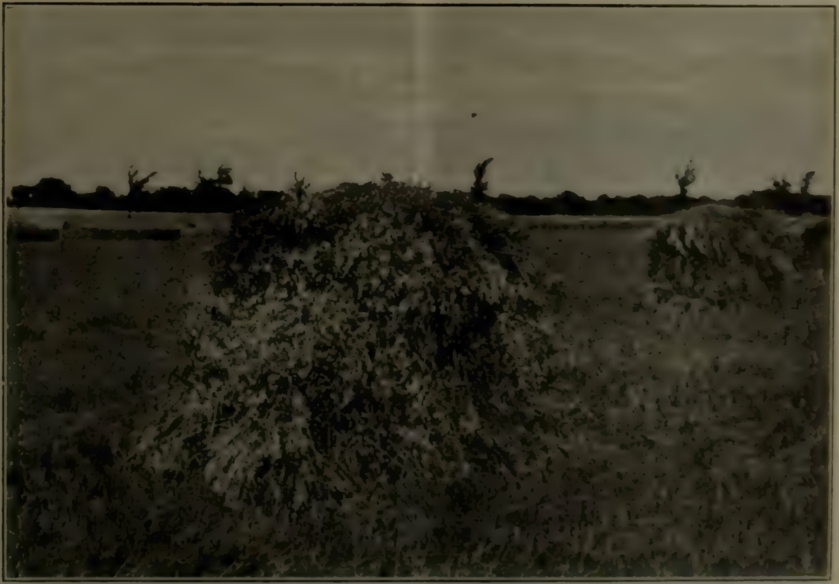

FIG. 8.—A well-built, round shock of oats, capped to protect most of the grain from weathering.

than 10 bundles may be placed in long shocks. In capping long shocks the first bundle should be put on with the butts pointing in the direction from which the prevailing winds come and covering the heads of the bundles in that end of the shock as completely as possible. The second cap should then be laid on the other end of the shock in the same manner, with the heads overlapping those of the first. Two bundles will cover an ordinary long shock with considerable overlap, but if the shock is very large more than two caps may be needed. A long, uncapped shock is shown in figure 9.

STACKING.

Whether oats should be stacked or allowed to remain in the shock until they are thrashed depends very largely on local conditions. If they can be thrashed from the shock after they are cured but before they are injured by weathering, the best course to pursue depends on the relative cost of shock and stack thrashing. Investigations show that stacking adds about 1 to 1½ cents a bushel to the cost of producing oats. As thrashing outfits are often not available when they are wanted and as consequently the grain is likely to be injured by weathering, stacking is generally advisable, particularly in the humid section.

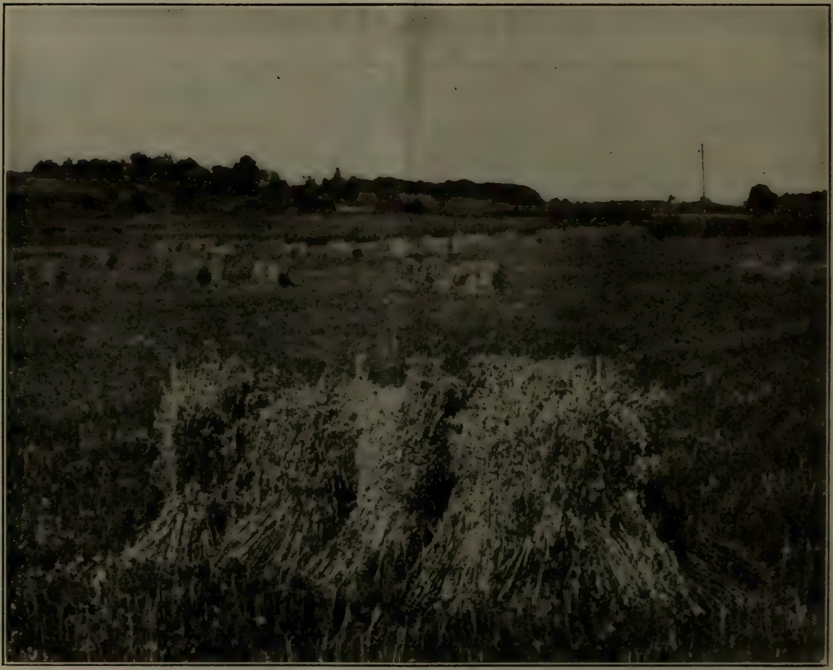

FIG. 9.—A long, uncapped shock of oats in which practically all the grain is exposed to the weather.

Where grain is stacked, it is important that the stacks be well built. If the stacks are put up so carelessly that they will not shed water, the grain might better be allowed to stand in the shocks. The bottoms of the stacks should be raised from the ground slightly by laying down old rails or other material to keep the straw from coming in contact with the earth, thus preventing the absorption of moisture from below. The shape of the stack is less important than the manner in which the bundles are laid, though round stacks probably shed water better than the long ricks sometimes built.

Stacking should be begun as soon as the grain is well cured in the shock, in about 10 days to 2 weeks after cutting. Round stacks are usually about 10 feet in diameter at the base. The usual plan is to build four stacks in a setting, in pairs 6 feet apart.

First build a large, round shock about 8 feet in diameter. Then place two layers of bundles, one directly on top of the other, with the heads resting against the shock and the butts forming the 10-foot base of the stack. Make the next row with the butts just covering the bands of the outer row. In the same manner lay rows of bundles, like shingles, until the center is reached, overlapping the rows a little more toward the center of the stack. When the first layer is completed, begin again at the outside and build toward the center.

Shocked bundles have slanting butts, because they are set in the shock with a slight slant instead of exactly upright. In building the outside rows around the stack lay the long edge of the butt on top and projecting beyond the lower bundle. In this way the diameter of the stack is gradually increased, forming the bulge. After a height of 7 or 8 feet is reached lay the outer bundles with the long edge of the butt beneath and just covering the inner edge of the layer just completed. In this way the diameter is gradually decreased and the stack is tapered slowly to a point.

Always keep the middle of the stack high and firmly tramped down. Do not tramp the outer layer at all. Keeping the middle high gives all the bundles a slant toward the outside and helps to shed rain. At the peak, where the bundles overlap, fasten a capsheaf securely by setting it on a sharpened stake driven into the top of the stack. A well-built stack 10 feet in diameter should be 20 to 25 feet high.

THRASHING.

As previously stated, it is cheaper to thrash directly from the shock if the work can be done while the grain is still in good condition. Thrashing from the shock is often subject to delay from rains, however, as the work must wait until the bundles are dry. This may mean the loss of one or even two or three days after heavy rains. On the other hand, if the grain is stacked, thrashing may be resumed almost as soon as the rain stops. Grain may be thrashed from the shock either before or after it has gone through the sweat. If it is thrashed before it goes through the sweat, it will sweat in the bin, but if it is dry when thrashed it will not be injured. If the grain is damp when thrashed, it sweats too much and is likely to become hot and be damaged by bin burning. Stacked grain should be allowed to go through the sweat before it is thrashed.

The separator should be well cleaned before thrashing is begun, particularly if it has come from a neighbor's farm where a different variety of oats is grown or if some other grain has just been thrashed. Cleaning the separator also prevents the bringing of weed seeds from other farms. The operation of the machine should be watched carefully to see that all the grain is removed from the straw. It is much easier to do a clean job of thrashing when the grain is dry than when it is moist.

The straw should be run into the mow, where it can be kept under cover or, if it must be stacked outside, the stack should be built carefully so that it will shed water. Oat straw is a valuable roughage for live stock, being much better for this purpose than the straw of wheat or barley. It is also of value for bedding and the making of manure, if it is not all needed for feed.

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BREEDS OF DAIRY CATTLE

H. P. DAVIS

Dairy Husbandman, Dairy Division

SUPERSEDED BY 1443

FARMERS' BULLETIN 893

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Animal Industry

JOHN R. MOHLER, Chief

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Washington, D. C. Issued November, 1917; revised September, 1920

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Dec. 6, 1920.

BREEDS of dairy cattle differ in both conformation and general characteristics. Each has been developed for certain ends. In selecting a breed for any dairy enterprise, consideration ought to be given to factors which will make for the success of that particular business.

The prevailing type of each breed and the ideal toward which the breeders are striving are described in this bulletin. Such information, together with a brief history of the origin and development of each breed, should be of value to the breeder in beginning and carrying on his breeding operations.

Only those breeds having a large representation in the United States are included in the discussion.

BREEDS OF DAIRY CATTLE.

CONTENTS.

	Page.
Factors to be considered in the selection of a breed	3
Origin and characteristics of the breeds	6
Ayrshire	6
Brown Swiss	12
Origin and characteristics, etc.—Con.	
Guernsey	17
Holstein-Friesian	22
Jersey	29
Parts of a cow	35

FACTORS TO BE CONSIDERED IN THE SELECTION OF A BREED.

CONDITIONS affecting dairying vary so greatly in the different sections of the United States that many things must be considered in the selection of a suitable breed of dairy cattle. Although the different dairy breeds are alike in general dairy tendencies, each breed has peculiarities which adapt it to certain conditions. Therefore, not only the conditions to be met but also the characteristics of the breed must be judged in order to make the wisest selection.

Two sources of income from dairy cattle are to be considered. One is represented by the sale of products, either milk or butterfat; and the other comes from the sale of surplus stock. Often the latter may amount to a considerable sum, even though the herd is composed of grade animals.

Another point that should be borne in mind is that no single breed is altogether superior to all others; it may excel in certain features, but not in all. It is best, therefore, to select the breed which comes the nearest to meeting the necessary conditions.

MARKET REQUIREMENTS.

Most of the milk sold in towns and cities is subject to certain requirements as to quality, among which are standards for the butterfat and milk solids. For a large percentage of the milk, payment is based upon quantity or weight, without special reference to any butterfat content above the legal standard. Local requirements differ greatly as to the butterfat and solids content, but the standard of the United States Department of Agriculture for use in inter-

NOTE.—H. P. Davis, author of this bulletin, resigned April 30, 1919; this revision has since been prepared in the Dairy Division.

state commerce of 3.25 per cent butterfat and 8.5 per cent solids not fat is a fair example of the quality of milk required. Many cheese factories and also some condensaries buy the milk on the weight basis, provided a certain minimum standard is reached. Recently it has become much more common among the buyers to purchase milk upon the basis of butterfat content. This basis is being adopted among the large dealers in cities, and it undoubtedly is a much fairer method than the straight-weight system. All creameries and ice-cream factories and many condensaries buy milk or cream on the butterfat basis, and a majority of cheese factories also have adopted this method of buying.

Consumers, as a rule, much prefer milk of a deep-yellow color, which usually is considered to be an indication of richness. A distinct and deep cream line in the milk bottle is another feature by which the quality of the milk is judged. Although generally the consumer does not want to pay more for a better quality of product, occasionally it is possible to create a demand for rich milk at a higher price.

BREED PREVAILING IN THE COMMUNITY.

Very often the benefits of cooperative effort are lost through the exercise of an inborn spirit of independence. Consequently it frequently happens that in the selection of a breed no consideration is given to the fact that a breed already may be established in the locality. The predominance of a certain breed in a community offers many advantages. A market is established which, because of the availability of large numbers of animals, attracts buyers from a distance, especially those who buy large consignments. Under such circumstances all surplus stock may be disposed of to better advantage and cooperative advertising also may be used effectively. In addition bulls may be bought cooperatively or exchanged with facility, thus very materially reducing the cost of service in the herd.

Any necessary additions to the herd can be obtained, without expense for travel, from neighbors' herds with whose history the buyer is thoroughly familiar. These advantages apply not only to the breeder of purebred cattle but also to the owner of grades.

PERSONAL PREFERENCE.

Personal preference is very important in choosing a breed, but too often it is the only thing considered, leading sometimes to the selection of a breed unsuited to local conditions, with resulting failure for the venture. While the greater the interest in any undertaking the more likely it is to be successful, a dairyman at least should consider his market and the community breed, as well as his own preference, in the matter of choosing a breed.

NATURE OF THE COUNTRY AND CLIMATE.

In this country there is a very wide range of conditions, as to both topography and climate. On rich, level pastures all breeds thrive, but on rough, hilly land, where pasturage is scant, they do not show equal adaptability. In the extreme cold of the North, with its long winters, different resisting qualities are needed as compared with the almost tropical heat in the southern parts of the country.

CURRENT PRICE OF THE BREED.

The prices of the several breeds of dairy cattle have been subject to considerable variation from year to year. Nearly all have had periods of "boom" when inflated prices were paid for animals. Just as a breed may enjoy a high tide of popularity, so it may suffer a period of depression. Frequently, during a period of depression, animals of good producing ability may be obtained at relatively small cost. A comparison of prices during several years will indicate the trend in value for any breed.

ESTIMATE OF THE FUTURE OF A BREED.

It is very difficult to arrive at a true estimate as to the future development and popularity of a breed, which is a matter of great importance to the breeder of purebred cattle and, to a less degree, to the breeder of grades, since a considerable part of the income from dairy cattle comes from the sale of surplus stock. A marked variation in the market price of cattle affects materially the returns from the dairy.

Perhaps one of the most common causes of fluctuation in price is the prevalence of fads, of which the most popular is color. Probably nothing retards the general development of a breed so much as these notions, which have no relation to the producing ability of animals.

There is a marked tendency toward larger size in dairy cattle because a larger animal, by its greater consumption of feed, has the possibility of greater production. Ordinarily, from the point of view of the added beef value, too much stress is placed upon size. This difference in value is so small as to be of little importance in comparison with other features.

PREPOTENCY.

The type of the breed should be well established if the breeder desires to have the characteristics of his animals transmitted to their offspring. In the case of grade herds it is especially desirable that the characteristics of the purebred bull be transmitted to his offspring. Females showing the external characteristics of their sire may reasonably be expected to have also some of the milk-producing ability of his ancestors.

SCORE CARDS.

Dairy cattle registry associations have found that in the development of a uniform conformation in their respective breeds it is helpful to establish an ideal toward which to work. As an aid, score cards, which place certain values on separate characteristics, have been adopted. In some instances great emphasis has been placed on certain points of conformation which it was desired to establish as characteristics of the breed. Score cards, therefore, from a general-production standpoint, do not represent necessarily the relative value of the points of the animal, but are useful to the breeder in indicating the ideals toward which the breed is being developed. For this reason the official score card adopted by each breed association is given in this bulletin.

ORIGIN AND CHARACTERISTICS OF THE BREEDS.

In the United States five breeds of dairy cattle have attained considerable prominence, namely, the Ayrshire, Brown Swiss, Guernsey, Holstein-Friesian, and Jersey. These breeds have been developed carefully for a considerable time for the purpose of dairy production, and in consequence each transmits its characteristics with regularity to its offspring. Certain distinct features distinguish each breed from the others, but all possess ability as milk producers. There is, of course, considerable variation in the characteristics of individuals within each breed. The description given in this bulletin refers to the general, or predominating, type.

AYRSHIRE.

ORIGIN AND HISTORY.

The Ayrshire breed originated in the county of Ayr, in southwestern Scotland. In that region, which borders on the Irish Sea, the surface is rolling and has much rough woodland. Pastures, therefore, are somewhat sparse and it is necessary for animals to graze large areas in order to obtain sufficient feed.

It is only within the last hundred years that Ayrshires have had a type well enough established to be entitled to the designation of breed. No exact account of the different infusions of blood of other breeds into the native Scotch cattle to form the Ayrshire breed is at hand. It is probable, however, that the Channel Islands, Dutch, and English cattle were all represented.

IMPORTATIONS AND DISTRIBUTION.

The first importation of Ayrshires to this country was made in 1822, since which time there have been frequent importations into both the United States and Canada. New England, New York, and Pennsylvania probably contain the largest number of representatives of the breed. There is a small distribution in the other Atlantic States and the Pacific Northwest. In Canada Ayrshires have had great popularity and the breed seems well able to withstand the rigors of the Canadian climate. The merits of the breed have not been advertised widely; consequently it is not well known in many sections of the United States.

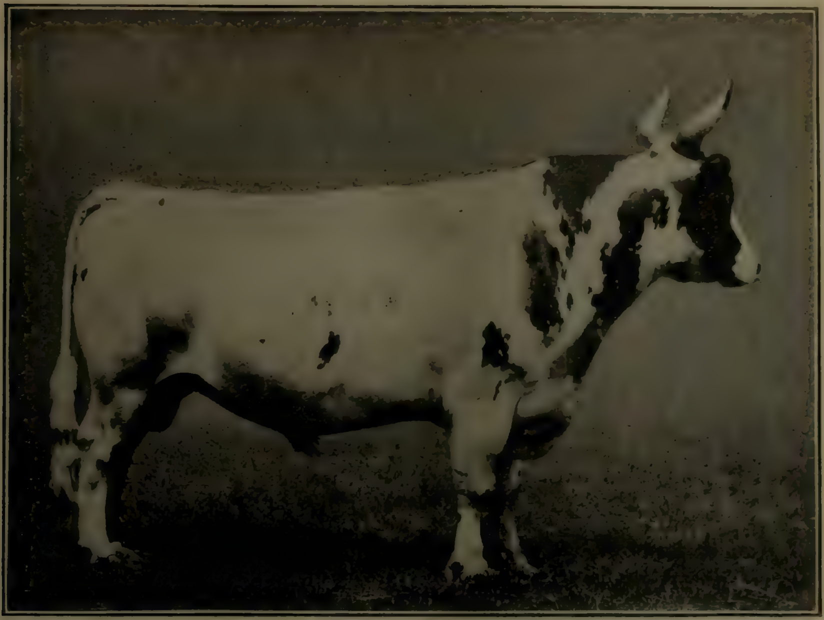

FIG. 1.—Ayrshire bull, Imp. Lessnessock MacDonald 13036.

CHARACTERISTICS.

The colors of Ayrshires may vary from a medium red to a very dark mahogany brown and white, with either color predominating. Of late years among breeders there has been a decided tendency toward white with red markings. A black muzzle and a white switch are desired, but are not necessary for registration. Perhaps the most picturesque feature of animals of the breed is their long horns, which turn outward, then forward and upward. Another point of which breeders of the Ayrshire are very proud is the uniform, square, level udder with long body attachment which is common among the cows.

Quick, brisk actions are characteristic of the animals, which seem always to have an abundant store of energy and to be exceptionally alert. Ayrshires have a highly nervous disposition, which is useful for both production and self-support. Probably none of the other dairy breeds can compare with the Ayrshires in ability to obtain a livelihood on scant pastures. Their ability as "rustlers" has made them very useful in sections where there is much rough land in pasture.

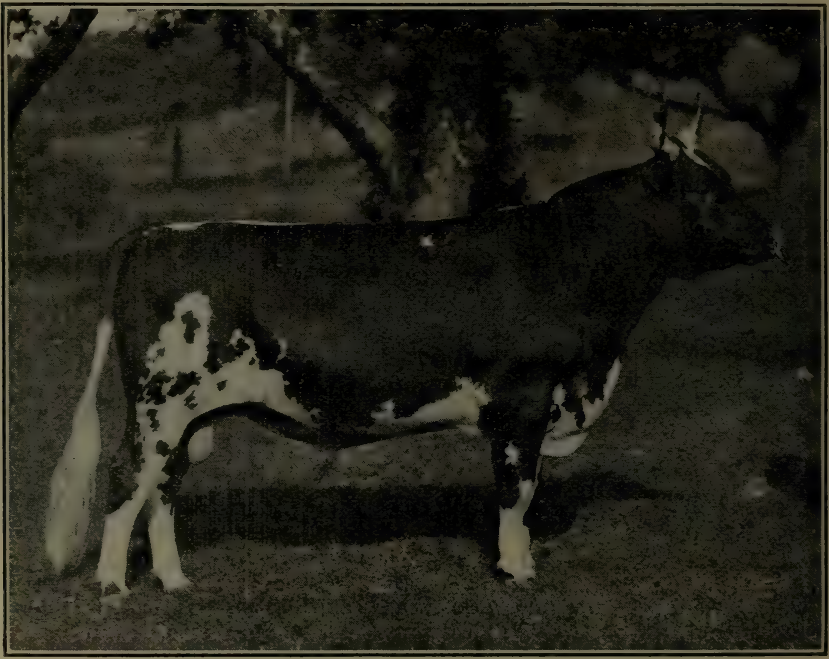

FIG. 2.—Ayrshire bull, Admiral Beatty of Wendover 20931.

In weight the cows may vary from 900 to 1,300 pounds (average about 1,000 pounds); bulls weigh between 1,400 and 2,000 pounds (average about 1,600 pounds). The animals are noticeably compact in body, with a tendency to smoothness over all parts. Formerly they were criticized for their short teats, but that fault has been removed largely by careful breeding. As a breed Ayrshires are generally very hardy and show great constitutional vigor.

At birth the calves weigh from 55 to 80 pounds, are very vigorous, easy to raise, and make rapid gains. Heifers reach maturity of frame at an age between the Holstein and the Jersey.

The scale of points for cows, adopted in 1906 by the Ayrshire Breeders' Association, is given below to show the points which breeders consider important:

Scale of points for Ayrshire cow.

	Points.
Head	10
Forehead: Broad and clearly defined	1
Horn: Wide set on and inclining upward	1
Face: Of medium length, slightly dished; clean cut, showing veins	2
Muzzle: Broad and strong without coarseness, nostrils large	1
Jaws: Wide at the base and strong	1
Eyes: Full and bright, with placid expression	3
Ears: Of medium size and fine, carried alert	1
Neck: Fine throughout, throat clean, neatly joined to head and shoulders, of good length, moderately thin, nearly free from loose skin, elegant in bearing	3
Fore quarters	10
Shoulders: Light, good distance through from point to point but sharp at withers, smoothly blending into body	2
Chest: Low, deep, and full between back and forelegs	6
Brisket: Light	1
Legs and feet: Legs straight and short, well apart, shanks fine and smooth, joints firm, feet of medium size, round, solid, and deep	1
Body	13
Back: Short and straight, chine lean, sharp, and open-jointed	4
Loin: Broad, strong, and level	2
Ribs: Long, broad, wide apart, and well sprung	3
Abdomen: Capacious, deep, firmly held up, with strong muscular development	3
Flank: Thin and arching	1

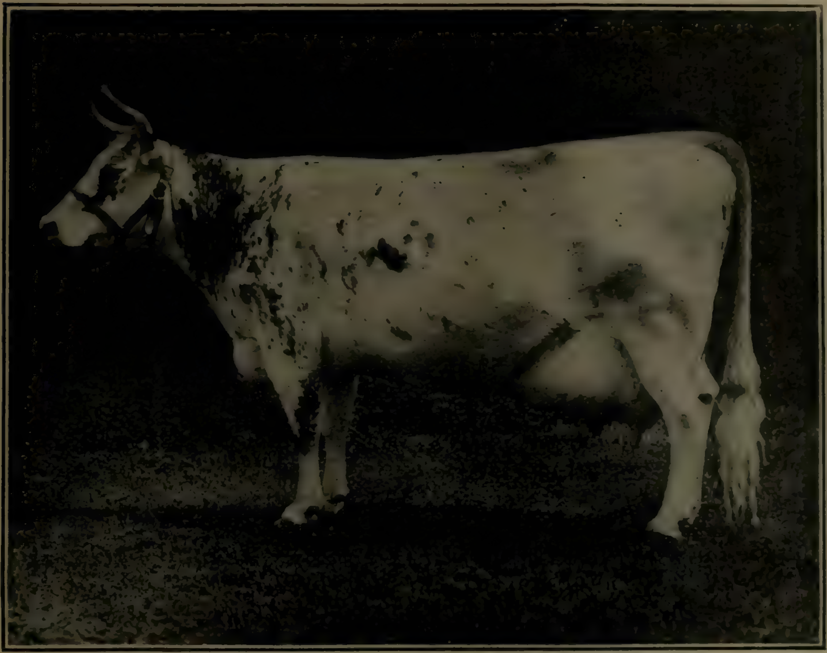

FIG. 3.—Ayrshire cow, Bloomer's Queen 30110.

	Points.
Hind quarters	11
Rump: Wide, level, long from hooks to pin bones, a reasonable pelvic arch allowed	3
Hocks: Wide apart and not projecting above back nor unduly overlaid with fat	2
Pin bones: High, wide apart	1
Thighs: Thin, long, and wide apart	2
Tail: Fine, long, and set on level with back	1
Legs and feet: Legs strong, short, straight, when viewed from behind and set well apart; shanks fine and smooth, joints firm, feet medium size, round, solid, and deep	2

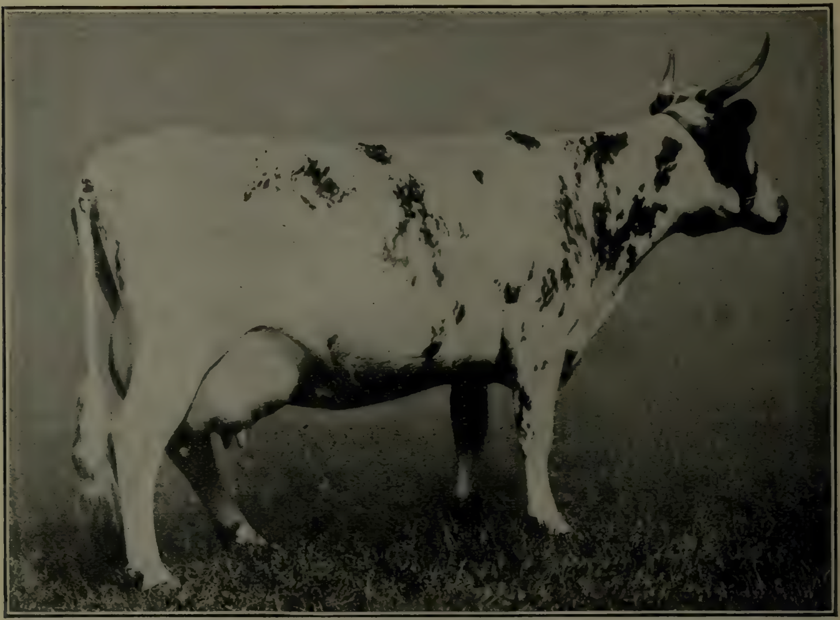

FIG. 4.—Ayrshire cow, Lily of Willowmoor 22269.

Udder, long, wide, deep, but not pendulous nor fleshy; firmly attached to the body, extending well up behind and far forward; quarters even; sole nearly level and not indented between teats, udder veins well developed and plainly visible	22
Teats, evenly placed, distance apart from side to side equal to half the breadth of udder, from back to front equal to one-third the length; length 2½ to 3½ inches, thickness in keeping with length, hanging perpendicular and not tapering	8
Mammary veins, large, long, tortuous, branching, and entering large orifices	5
Escutcheon, distinctly defined, spreading over thighs and extending well upward	2
Color, red of any shade, brown, or these with white; mahogany and white, or white, each color distinctly defined. (Brindle markings allowed but not desired.)	2

	Points.
Covering	6
Skin, medium thickness, mellow and elastic	3
Hair, soft and fine	2
Secretions, oily, of rich brown or yellow color	1
Style, active, vigorous, showing strong character, temperament inclined to nervousness but still docile	4
Weight, at maturity not less than 1,000 pounds	4
Total	100

PRODUCTION.

Milk from Ayrshire cows contains comparatively little color and has the fat in uniformly small globules which average smaller in size than in any other breed. For these reasons the milk sometimes fails to show a distinct cream line, by which the consumer often judges the quality of the milk. Ayrshire milk, because of the small fat globules, stands shipping well without churning, and in other respects it is well adapted to the market-milk trade. The percentage of the butterfat in the milk is medium, and consequently there is no difficulty in conforming to local or State butterfat standards.

The average of the 3,319 cows and heifers that have completed yearly records for advanced registry[1] to June 5, 1919, is 9,621 pounds of milk, testing 3.96 per cent of butterfat, amounting to 381.20 pounds of fat. The 10 highest producers of the breed for milk and butterfat to January, 1920, are given below:

Ten highest milk producers among Ayrshires.

	Pounds of milk.
1. Garclaugh May Mischief 27944	25,329
2. Auchenbrain Brown Kate 4th 27943	23,022
3. Lily of Willowmoor 22269	22,596
4. Garclaugh Spottie 27950	22,589
5. Jean Armour 3d 32219	21,938
6. Bloomer's Queen 39119	21,938
7. Auchenbrain Yellow Kate 3d 36910	21,123
8. Gerranton Dora 2d 23853	21,023
9. Jean Armour 25487	20,174
10. Canary Bell 25748	19,863
Average	21,959.5

Ten highest butterfat producers among Ayrshires.

	Pounds of milk.	Pounds of butterfat.
1. Lily of Willowmoor 22269	22,596	955.56
2. Auchenbrain Brown Kate 4th 27943	23,022	917.60
3. Garclaugh May Mischief 27944	25,329	894.91

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[1] SPECIAL REGISTRATION OF HIGH PRODUCERS.—For each of the breeds discussed in this bulletin there is a register in which purebred cows that have completed milk and butterfat records under definite regulations are entered. These registers are called: For Ayrshires, advanced registry; for Guernseys and Holsteins, advanced register; for Brown Swiss, register of production; and for Jerseys, register of merit. Bulls are entered in these special registers when a certain number of their daughters have been entered.

	Pounds of milk.	Pounds of butterfat.
4. Auchenbrain Yellow Kate 3d 36910	21, 123	888. 33
5. Jean Armour 3d 32219	21, 938	859. 65
6. Bloomer's Queen 39119	21, 820	856. 41
7. August Lassie 29581	19, 582	831. 50
8. Agnes Wallace of Maple Grove 25171	17, 657	821. 45
9. Netherhall Brownie 9th 23985	18, 110	820. 91
10. Garclaugh Spottie 27950	22, 589	816. 25
Average	21, 376. 6	866. 26

FAMILIES.

On account of the comparatively recent origin of the breed few families have been developed. The more prominent in the United States are the Brownie, Auchenbrain, Finlayston, White Cloud, Jean Armour, and Robin Hood.

BULLS.

The 10 Ayrshire bulls having the largest number of daughters with advanced-registry records to October, 1919, are listed below, together with the average production of their daughters.

Ten Ayrshire bulls with largest number of advanced-registry daughters.

	Number of daughters.	Average pounds of milk.	Average pounds of butterfat.
1. Finlayston 8882	51	10, 421	431
2. Beuchan Peter Pan 12971	51	9, 890	394
3. Earl's Choice of Spring Hill 8289	42	9, 061	380
4. Nox'emall 7312	35	9, 772	373
5. White Cloud of Hickory Island 10377	32	11, 276	440
6. Morton Mains' Queechy 11537	27	9, 890	400
7. Willowmoor Robin Hood 11900	23	9, 820	432
8. Moonstone of Drumsule 8228	22	8, 778	357
9. Howie's Dairy King 9855	21	11, 695	457
10. Holehouse White King 10348	19	10, 386	403

ORGANIZATION.

The official organization of the Ayrshire breed in the United States is the Ayrshire Breeders' Association, with headquarters at Brandon, Vt. The secretary resides there and has charge of both registration and advanced-registry work.

BROWN SWISS.

ORIGIN AND HISTORY.

The Brown Swiss breed originated in the Canton of Schwyz, in eastern central Switzerland. The cattle are called variously Brown Switzer, Brown Schwyzer, and Brown Swiss, the last name being the one commonly used in the United States. Conditions in Switzerland are such that a strong animal capable not only of milk production but of service as a draft animal is desired, and the large frame is evidence of fitness for these requirements.

IMPORTATIONS AND DISTRIBUTION.

The first importation into the United States was made in 1869, and although other importations have been made since, comparatively few animals have been brought to this country. Quarantine regulations in the United States against contagious animal diseases on the Continent of Europe probably have hindered the introduction of large numbers of these animals. The distribution in the United States is not widespread, the cattle being found principally in the States of New York and Wisconsin. The present popularity of the Brown Swiss has been gained entirely by the merits of the animals, as they have not been much advertised.

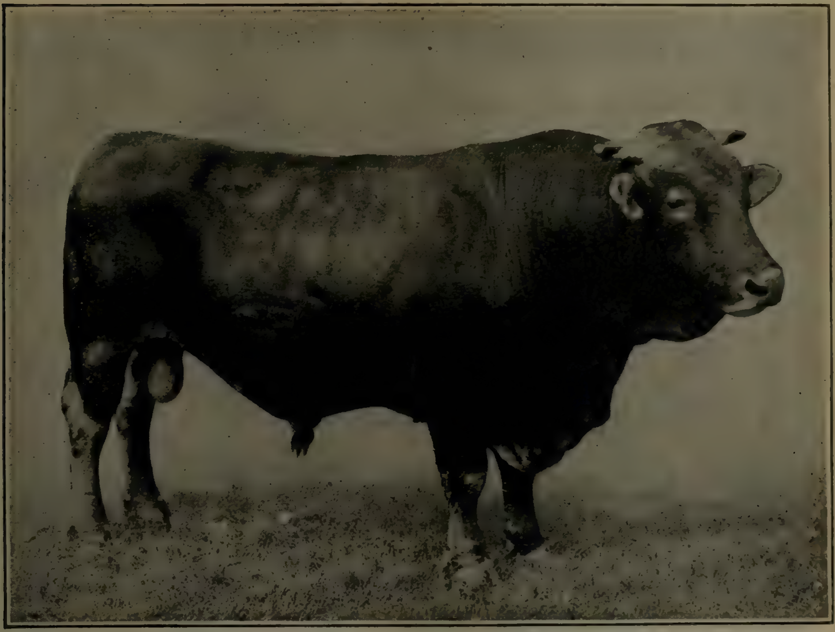

FIG. 5.—Brown Swiss bull, Imp. Junker 2365.

CHARACTERISTICS.

In color the cattle vary from a light-gray, mouse color, or brownish dun to dark brown. A medium shade of brown shading into a light gray or almost white strip along the backbone and on the belly is preferred. The udder is usually white, switch of tail and hoofs black. A black muzzle with a creamy or mealy ring around it is characteristic. The horns, of medium size, are white at the base and black at the tip. In disposition the cattle are mild and docile and for their size are very active; they are excellent grazers, especially on rough land.

The cows when mature weigh from 1,100 to 1,600 pounds (average about 1,250 pounds); bulls range from 1,500 to 2,500 pounds. The cattle are compact, smoothly fleshed over all parts, and when dry rapidly put on flesh, which is milked off well after freshening. Straightness of hind legs is a typical characteristic of the breed.

The breed has been criticized because certain animals have shown lack of regularity in type of udder and have had exceptionally large teats. As the breeders pay more attention to these points great improvement is observed.

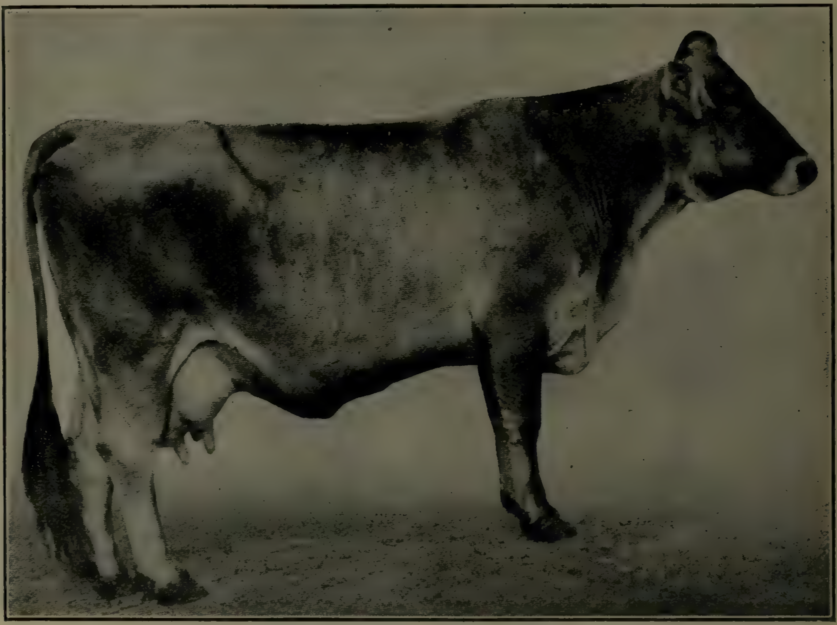

FIG. 6.—Brown Swiss cow, College Bravura 2d 2577.

Calves at birth are large and vigorous and weigh from 65 to 90 pounds. As a rule, animals of the breed are somewhat slower in maturing than those of other dairy breeds.

The scale of points for cows, adopted by the Brown Swiss Cattle Breeders' Association, is given below:

Scale of points for Brown Swiss cow.

	Points.
Head, medium size and rather long	2
Face, dished, narrow between horns and wide between eyes	2
Ears, large, fringed inside with light-colored hair, skin inside of ear a deep orange color	2
Nose, black, large, and square, with mouth surrounded by neatly colored band, tongue black	2
Eyes, moderately large, full, and bright	2

	Points.
Horns, short, regularly set, with black tips	2
Neck, straight, throat clean, neatly joined to head, shoulders of good length, moderately thin at the withers	4
Chest, low, deep, and full between and back of forelegs	6
Back, level to setting of tail and broad across the loin	6
Ribs, long and broad, wide apart and well sprung, with thin, arching flanks	3
Abdomen, large and deep	5
Hips, wide apart, rump long and broad	4
Thighs, wide, quarters not thin	4
Legs, short and straight with good hoofs	2
Tail, slender, well set on, with good switch	2
Hide of medium thickness, mellow and elastic	3
Color shades from dark to light brown, at some seasons of the year gray; white splashes near udder not objectionable; light stripe along back; white splashes on body or sides objectionable; hair between horns usually lighter shade than body	4
Fore udder, wide, deep, well rounded, but not pendulous nor fleshy, extending far forward on the abdomen	12
Rear udder, wide, deep, but not pendulous nor fleshy, extending well up behind	12
Teats, rather large, set well apart, and hanging straight	8
Milk veins large, long, tortuous, elastic, and entering good wells	6
Disposition, quiet	2
Size, evidence of constitution, and stamina	5
	100

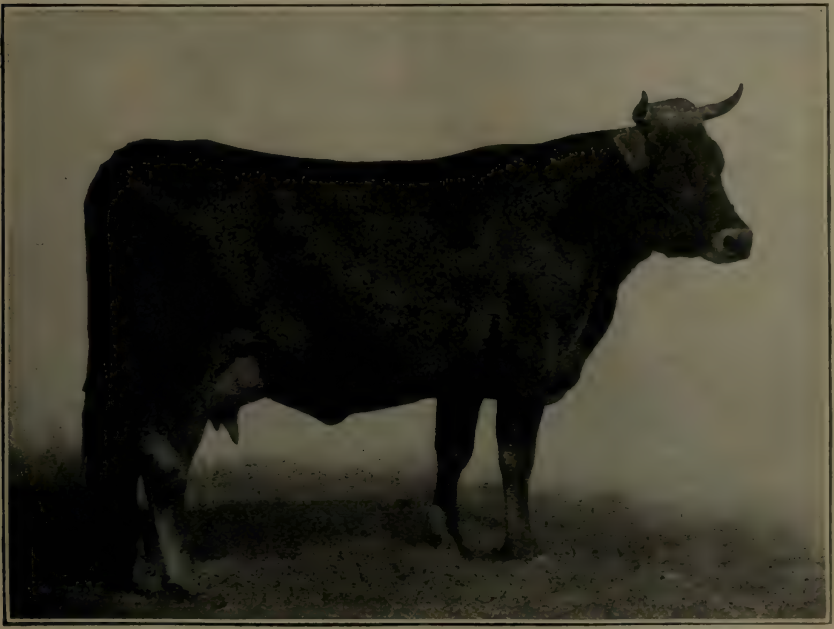

Fig. 7.—Brown Swiss cow, Vogel 3464.

PRODUCTION.

In milk production this breed ranks well, with a moderate percentage of fat. The average of the 228 cows that have completed yearly records of production to January 1, 1918, is 10,931.1 pounds of milk testing 3.998 per cent, amounting to 437.02 pounds of butterfat.

The 10 highest milk and butterfat producers of the breed to October 13, 1919, are given below:

Ten highest milk producers among Brown Swiss.

	Pounds of milk.
1. College Bravura 2d 2577	19, 460. 6
2. Ethel B. 3842	18, 816. 2
3. Lottie G. B. 3530	17, 595. 3
4. Brownie F. 4855	17, 420. 8
5. Nan of Lake View 4061	17, 136. 4
6. Iola 3923	16, 844. 6
7. Rosalind B. 3905	16, 804. 4
8. Miss Salem 3573	16, 658. 0
9. Kaliste W. 2905	16, 609. 2
10. Flora Duwire 4105	16, 538. 1
Average	17, 388. 4

Ten highest butterfat producers among Brown Swiss.

	Pounds of milk.	Pounds of butterfat.
1. College Bravura 2d 2577	19, 460. 6	798. 16
2. Ethel B. 3842	18, 816. 2	779. 97
3. Rosalind B. 3905	16, 804. 4	727. 64
4. Iola 3923	16, 844. 6	685. 47
5. Edna C. 3d 5092	16, 496. 7	669. 35
6. Lottie G. D. 3530	17, 595. 3	664. 25
7. Brownie F. 4855	17, 420. 8	662. 25
8. Buenna F. 4279	15, 957. 8	654. 97
9. Kaliste W. 2905	16, 609. 2	650. 32
10. Flora Duwire 4105	16, 538. 1	649. 42
Average	17, 254. 4	714. 18

FAMILIES.

Families of Brown Swiss have not been developed to any great extent in this country.

BULLS.

Only a few bulls have more than one daughter in the register of production[1]; the 13 with the largest number of daughters to June, 1917, are:

McAvoy 2068.
Zell 2512.
Reuben 2927.
Casper C. 1999.
Ben Hanson 2373.
Collier 2075.
Junker 2365.
Mack W. 2901.
Ueeta's Son 1747.
Richard Esmond 1342.
Speedwell 2582.
Billy B. 2769.
Carl 3577.

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[1] See footnote on page 11.

ORGANIZATION.

The official organization of the Brown Swiss breed in the United States is the Brown Swiss Cattle Breeders' Association, and the secretary for both registration and register of production resides at Beloit, Wis.

GUERNSEY.

ORIGIN AND HISTORY.

The Guernsey breed had its early development on the Channel Islands of Guernsey and Alderney, and at present cattle from either island are eligible to registry in the herdbook of the American Guernsey Cattle Club. The origin of the breed is obscure, but it is probable that the parent stock came from Normandy, France, which is adjacent to the islands. Early livestock laws of the islands prevented the importation of livestock for any purpose except slaughter, and under these conditions, in the course of the last century, the cattle developed into a distinct breed.

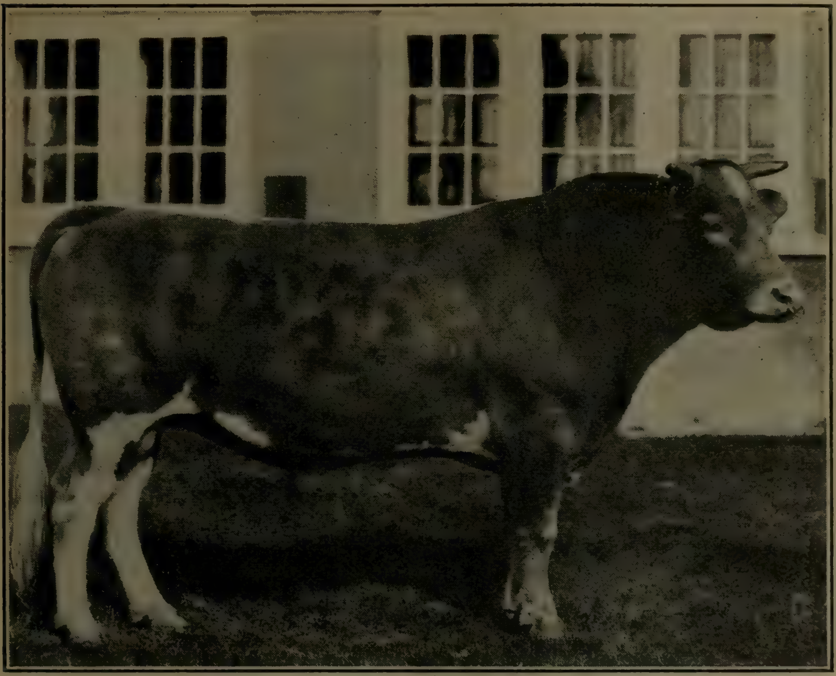

FIG. 8.—Guernsey bull, King of Chilmark 20798.

The climate of the Channel Islands, being mild throughout the year, allows a long grazing season.

Although they come from the same parent stock, Guernseys are larger than their companion breed, the Jerseys, and are unlike them in some other respects, having been developed by men with different ideals.

IMPORTATIONS AND DISTRIBUTION.

The first representatives of the breed were imported in the early part of the nineteenth century, but not until 1878 were efforts made to keep the breeding pure in this country by the establishment of a herd register. Since that time there have been importations almost every year, and the breed has maintained a steady growth in numbers and popularity. About 50 per cent of their numbers are found east of the Alleghanies, but they are spreading westward.

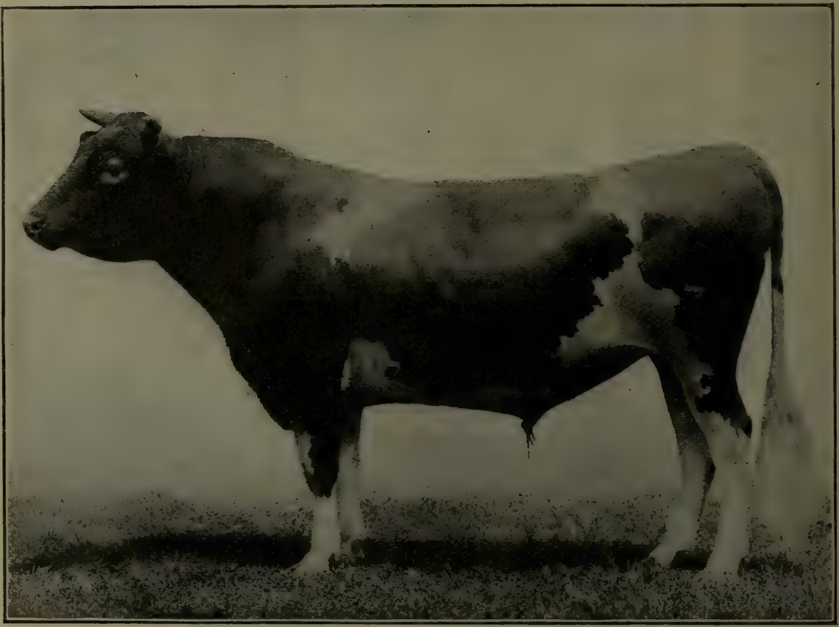

FIG. 9.—Guernsey bull, Imp. King of the May 9001.

CHARACTERISTICS.

The characteristic colors of Guernseys are some shade of fawn and white. The former varies from a very light orange fawn to a deep reddish or brownish fawn. An orange fawn with white markings, the fawn predominating, is perhaps the most common. The under parts of the body, legs, and switch of tail are usually white. A buff nose and amber-colored horns of medium size are typical of the breed. A rich yellow secretion of the skin is most highly thought of by breeders and is considered as an indication of the quality of the milk, which is rich in fat and highly colored.

Guernseys possess a nervous temperament, but are very quiet and gentle if properly handled and are not easily excited.

A lack of uniformity among Guernseys is perhaps the most serious criticism that can be made, but this defect is being remedied rapidly through the efforts of the breeders, and during the last few years a great improvement in this respect has been noted.

Guernseys are medium in size. The cows vary in weight from 900 to 1,400 pounds (average about 1,050 pounds); the bulls range from 1,400 to 2,200 pounds (average about 1,600 pounds). There is some resemblance between the Guernsey and the Jersey, but the former is larger and slightly coarser boned, with a deeper and more "rangy" body. The head also is somewhat longer and more narrow than that of the Jersey.

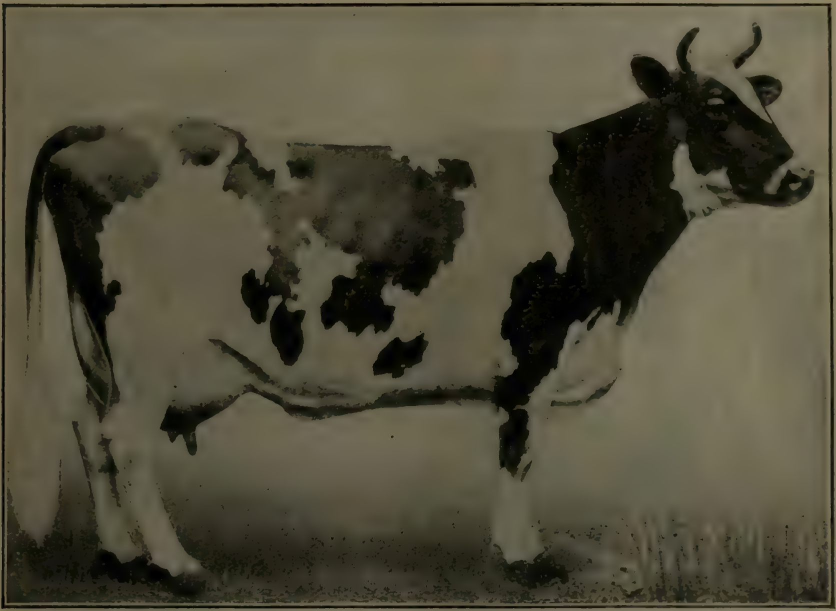

FIG. 10.—Guernsey cow, Glencoe's Bopeep 18602.

The birth weight of calves ranges from 60 to 85 pounds. Heifers reach maturity a little later than Jerseys and earlier than the other breeds.

The scale of points for cows, adopted in May, 1918, by the American Guernsey Cattle Club, is given below:

Scale of points for Guernsey cow.

	Points.
Head: Clean cut, lean face, wide mouth and muzzle, with open nostrils, full, bright eye, with gentle expression. Forehead long, broad between the eyes and dishing	6
Horns: Small at base, medium length, not too spreading	1
Neck: Long and thin; clean throat	2

	Points.
Withers: Chine rising above shoulder blades that are moderately thick and not coarse	3
Back: Straight from withers to hips	8
Hips: Wide apart, not too prominent	2
Rump: Long, continuing, with level of the back, also level between hip bones and pin bones	5
Thurls: Wide apart and high	2
Chest: Wide and deep at heart, with least depression possible back of the shoulders	4
Body: Deep and long, with well-sprung ribs, which are wide apart. Broad loin. Thin arching flank	10
Thighs: Thin, incurving seen from side, and wide apart from rear	2

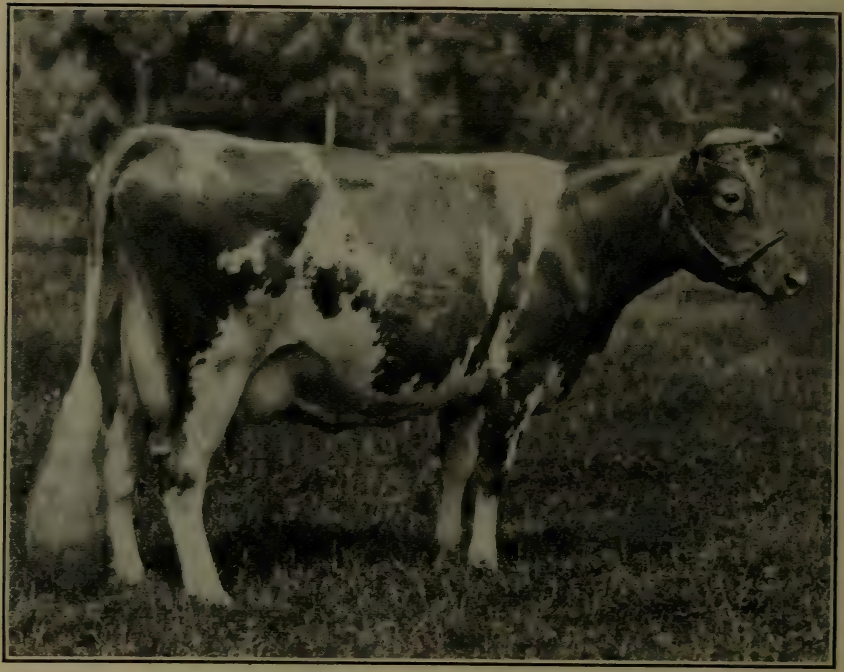

Fig. 11.—Guernsey cow, Langwater Dairymaid 26377.

Legs: Comparatively short, clean, wide apart, and nearly straight when viewed from behind, squarely set under body	2
Hide: Loose and pliable, and not thick, with oily feeling	3
Tail: Neat and firm setting on; long, good switch	1
Udder:	
Veins prominent	2
Attachment to body long and wide	2
Extending well forward	5
Level and well up behind	4
Teats of good, even size, well apart, and squarely placed	5
Milk veins: Long, crooked, branching, and prominent, with large, deep wells	4

	Points.
Secretions indicating color of product: Indicated by the depth of yellow, inclining toward orange of the pigment secretion in the skin, on the body generally, and especially discernible in the ear, at the end of bone of tail, around the eye, on the udder and teats, and at the base of horns. Hoofs and horns amber color	20
Color markings: A shade of fawn with white markings	2
Size: Mature cows about 1,100 pounds in milking condition	5
	100

PRODUCTION.

Milk from Guernsey cows is noted for its extremely yellow color and high percentage of butterfat. The fat globules are larger than those in milk from either Holstein or Ayrshire cows, and consequently the cream rises more rapidly upon setting. Guernseys are particularly adapted for the production of butterfat or cream or for rich milk at a special price.

The average of 8,896 cows that have completed a year's record for the advanced register[1] to January 15, 1920, is 9,030.5 pounds of milk testing 5.015 per cent, amounting to 452.97 pounds of butterfat.

The 10 highest milk and butterfat producers of the breed to January 15, 1920, were as follows:

Ten highest milk producers among Guernseys.

	Pounds of milk.
1. Murne Cowan 19597	24,008.0
2. Nella Jay 4th 38233	20,709.9
3. Langwater Hope 27946	19,882.0
4. Yeksa's Tops of Gold's Fannie 22362	19,794.9
5. May Rilma 22761	19,673.0
6. Belladia 31909	19,631.9
7. Cinderella Josephine 34600	19,460.5
8. Ada of Tamworth II 43614	18,857.4
9. Dolly Dimple 19144	18,808.5
10. Langwater Nancy 27943	18,783.5
Average	19,961.0

Ten highest producers of butterfat among Guernseys.

	Pounds of milk.	Pounds of butterfat.
1. Murne Cowan 19597	24,008.0	1,098.18
2. May Rilma 22761	19,673.0	1,073.41
3. Nella Jay 4th 38233	20,709.9	1,019.25
4. Langwater Nancy 27943	18,783.5	1,011.66
5. Langwater Hope 27946	19.882.0	1,003.17
6. Yeksa's Tops of Gold's Fannie 22362	19,794.9	981.53
7. Spotswood Daisy Pearl 17696	18,602.8	957.38
8. Julie of the Chêne 30460	17,661.0	953.53
9. Bijou des France 44541	17,104.0	943.41
10. Belladia 31909	19,631.9	934.05
Averages	19,585.1	997.56

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[1] See footnote on page 11.

FAMILIES.

There are a number of well-developed families of Guernseys, of which the following are among the more widely known: May Rose, Glenwood, Masher's Sequel, Governor of the Chêne, Yeksa, Tricksey, and Sheet Anchor.

BULLS.

Some of the leading sires, with their advanced-register progeny, are given below. They are arranged according to the number of their advanced-registry daughters April 28, 1920.

Ten Guernsey bulls with largest number of advanced-register daughters.

Bull.	Number of daughters.	Average pounds of milk.	Average pounds of butterfat.	Average age, years-months.
Governor of the Chêne, R. G. A. S. 1297 P. S	99	9,281.37	457.22	4–5
Masher's Sequel, 11462	70	10,048.54	463.68	5–1
Galaxy's Sequel, 16904	45	9,306.04	471.05	4–2
Cora's Governor of the Chilmark, 8971	41	9,541.69	478.62	3–8
Justinée's Sequel of the Préel, R. G. A. S. 2119 P. S	35	8,943.81	457.79	3–6
Yeoman's King of the May, 17053	35	8,759.00	446.99	3–1
Masher, R. A. A. S. 63 F. S	32	8,706.06	410.05	4–4
Clara's Sequel, 29414	32	9,778.57	478.88	3–4
King of the May, 9001	30	12,269.23	618.53	4–2
Princess's Jewel, 24877	30	9,413.71	460.77	4–7

ORGANIZATION.

The official organization of the Guernsey breed in the United States is the American Guernsey Cattle Club, and the secretary for both registration and advanced register resides at Peterboro, N. H.

HOLSTEIN-FRIESIAN.

ORIGIN AND HISTORY.

In the low countries bordering on the North Sea, especially in the northern part of Holland, Holstein-Friesian cattle have been bred for centuries. The land is rich and fertile and pastures are exceptionally good. Different names have been used to designate the breed, both in Europe and America, among which the following are the more common: North Hollander, Holland, Netherland, Holstein-Friesian, Dutch, Dutch-Friesian, and Holstein. The last is the name usually used in this country, although Holstein-Friesian is the official name.

IMPORTATIONS AND DISTRIBUTION.

The Dutch settlers in the State of New York probably were the first to import individuals of the Holstein-Friesian breed, but the first importations of which records exist were made between 1857 and 1862 by Mr. W. W. Chenery, of Massachusetts, and many of our present-day animals are descended from these importations. For a time the trade in imported Holsteins flourished, but in recent years very few animals have been imported, owing largely to the quarantine which, on account of contagious animal diseases, has been in effect a large part of the time against continental European countries.

Holsteins have grown greatly in numbers and popularity in recent years, owing in a great degree to the increased demands of large cities for market milk. Cattle of the breed are most numerous in the Eastern and Middle Atlantic States, with the Middle Western and Pacific sections next in order. With the exception of the Jersey, there are more Holstein cattle in the United States than of any other dairy breed.

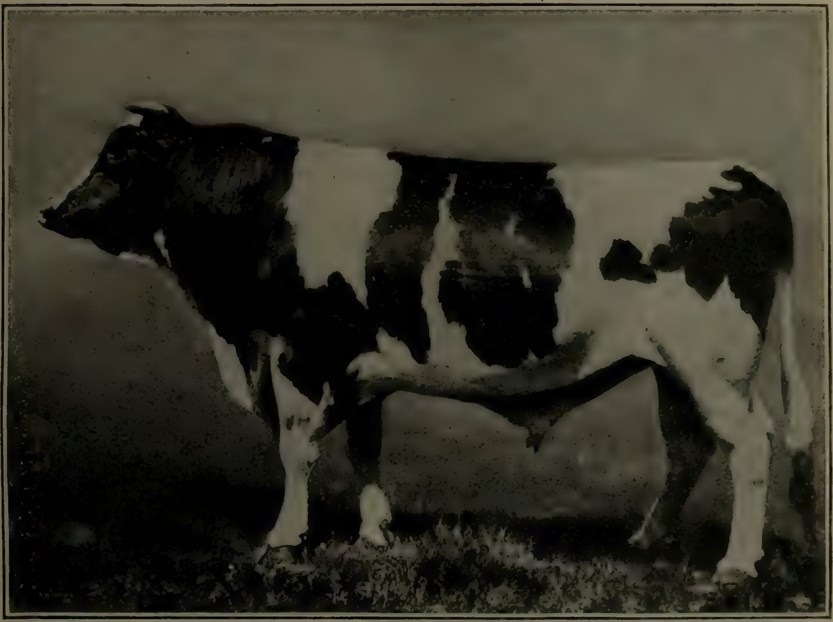

FIG. 12.—Holstein-Friesian bull, King of the Pontiacs, 39037.

CHARACTERISTICS.

A universal characteristic of the Holstein-Friesian cattle is the black and white color of their coats. The sharply defined and contrasting colors of jet black and pure white give them a very striking appearance. Although either color may predominate, black below the knees is objectionable. Purebred animals with any red or gray in their coats are ineligible to registry.

In disposition Holsteins are docile, even tempered, and not excitable; in fact, they are rather lazy in general habits, as shown in their poor "rustling" ability in grazing scanty pastures. They are large consumers of feed, especially roughage, and do best when plenty is readily available.

The Holstein is the largest of the dairy breeds. It has a large, bony frame, which often is smoothly covered over all parts. Cows at maturity vary in weight from 1,100 to 1,800 pounds (average about 1,250 pounds); bulls range from 1,500 to 2,600 pounds (average about 1,800 pounds). The calves are usually thrifty and vigorous at birth and make rapid growth. The birth weight varies from 70 to 110 pounds, in some cases exceeding even the latter figure. Heifers reach maturity in frame at about 4 years, although increases in body weight occur up to 6 or 7 years of age. As a breed the Holstein shows good constitutional vigor. The breed has been criticised for irregular udders and sloping rumps, but these defects are being remedied.

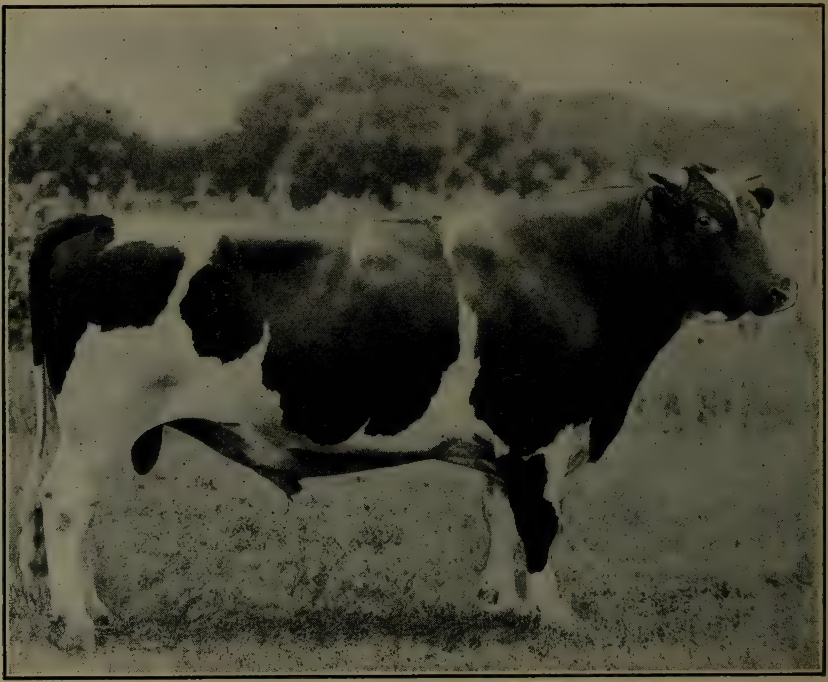

FIG. 13.—Holstein-Friesian bull, Sir Pietertje Ormsby Mercedes 14th 81142.

In order to show the general characteristics which the breeders consider desirable, the scale of points for cows, revised and adopted in June, 1904, by the Holstein-Friesian Association of America, is given as follows:

Scale of points for Holstein-Friesian cow.

[The interlines in smaller type relate entirely to the method of application agreed upon by the judges in order to secure uniformity of work. The abbreviations are as follows: vs, very slight; s, slight; m, marked; vm; very marked; e, extreme.]

	Possible score.
Head: Decidedly feminine in appearance, fine in contour **Discredit, vs ⅛, s ¼, m ½, vm ¾, e 1.**	2
Forehead: Broad between the eyes, dishing **Discredit, vs ⅛, s ¼, m ½, vm ¾, e 1.**	2
Face: Of medium length, clean and trim, especially under the eyes, showing facial veins; the bridge of the nose straight **Discredit, s ⅛, m ¼, e ½.**	2
Muzzle: Broad, with strong lips **Discredit, s ⅛, m ¼, e ½.**	1

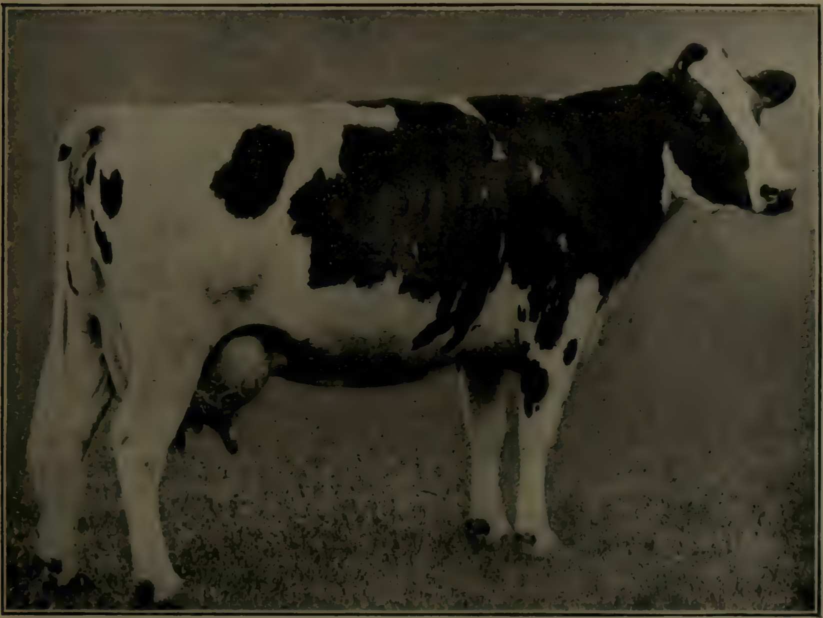

FIG. 14.—Holstein-Friesian cow, Duchess Skylark Ormsby 124514.

Ears: Of medium size, of fine texture, the hair plentiful and soft, the secretions oily and abundant **Discredit, m ⅛, e ¼.**	1
Eyes: Large, full, mild, bright **Discredit, s ⅛, m ¼, e ½.**	2
Horns: Small, tapering finely toward the tips, set moderately narrow at base, oval, inclining forward, well bent inward, of fine texture, in appearance waxy **Discredit, m ⅛, e ¼.**	1
Neck: Long, fine and clean at juncture with the head, free from dewlap, evenly and smoothly joined to shoulders **Discredit, vs ⅛, s ¼, m ½, vm ¾, e 1.**	4
Shoulders: Slightly lower than the hips, fine and even over tops, moderately broad and full at sides **Discredit, vs ⅛, s ¼, m ½, vm ¾, e 1.**	3
Chest: Of moderate depth and lowness, smooth and moderately full in the brisket, full in the foreflanks (or through at the heart) **Discredit, vs ¼, s ½, m 1, vm 1½, e 2.**	6

	Possible score.
Crops: Moderately full	2
Discredit, vs ⅛, s ¼, m ½, vm ¾, e 1.	
Chine: Straight, strong, broadly developed, with open vertebræ	6
Discredit, vs ⅛, s ¼, m ½, vm ¾, e 1.	
Barrel: Long, of wedge shape, well rounded, with a large abdomen trimly held up; (in judging the last item, age must be considered)	7
Discredit, vs ⅛, s ¼, m ½, vm ¾, e 1.	
Loin and hips: Broad, level or nearly level between the hook bones, level and strong laterally, spreading out from chine broadly and nearly level, hook bones fairly prominent	6
Discredit, vs ⅛, s ¼, m ½, vm ¾, e 1.	

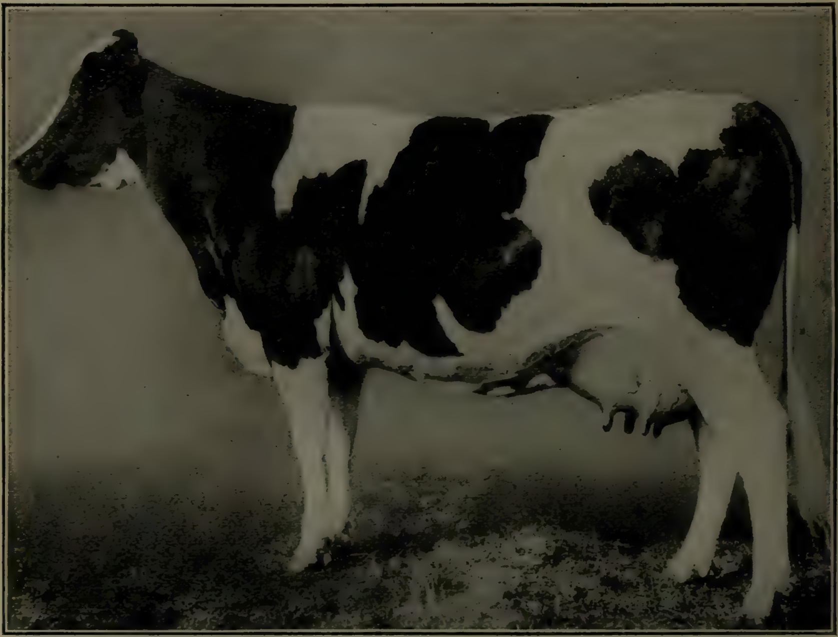

FIG. 15.—Holstein-Friesian cow, Tilly Alcartra 123459.

Rump: Long, high, broad with roomy pelvis, nearly level laterally, comparatively full above the thurl, carried out straight to dropping of tail	6
Discredit, vs ⅛, s ¼, m ½, vm ¾, e 1.	
Thurl: High, broad	3
Discredit, vs ¼, s ½, m 1, vm 1½, e 2.	
Quarters: Deep, straight behind, twist filled, with development of udder, wide and moderately full at the sides	4
Discredit, vs ⅛, s ¼, m ½, vm ¾, e 1.	
Flanks: Deep, comparatively full	2
Discredit, vs ⅛, s ¼, m ½, vm ¾, e 1.	
Legs: Comparatively short, clean and nearly straight, wide apart, firmly and squarely set under the body; feet of medium size, round, solid, and deep	4
Discredit, vs ⅛, s ¼, m ½, vm ¾, e 1.	
Tail: Large at base, the setting well back, tapering finely to switch, the end of the bone reaching to hocks or below, the switch full	2
Discredit, s ⅛, m ¼, e ½.	

	Possible score.
Hair and handling: Hair healthful in appearance, fine, soft, and furry; the skin of medium thickness and loose, mellow under the hand; the secretions oily, abundant, and of a rich brown or yellow color Discredit, vs ¼, s ½, m 1, vm 1½, e 2.	8
Mammary veins: Very large, very crooked (age must be taken into consideration in judging of size and crookedness), entering very large or numerous orifices, double extension, with special developments, such as branches, connections, etc Discredit, vs ¼, s ½, m 1, vm 1½, e 2.	10
Udder: Very capacious, very flexible, quarters even; nearly filling the space in the rear below the twist, extending well forward in the front, broad and well held up Discredit, vs ¼, s ½, m 1, vm 1½, e 2.	12
Teats: Well formed, wide apart, plump and of convenient size Discredit, vs ⅛, s ¼, m ½, vm 1, e 1½.	2
Escutcheon: Largest, finest Discredit, vs ⅛, s ¼, m ½, vm ¾, e 1.	2
	100

PRODUCTION.

From the point of view of quantity of milk produced, Holsteins average higher than any other breed. The percentage of butterfat, however, which averages lower than that of any other dairy breed, tends to counterbalance the advantage of a greater milk production. The butterfat of Holstein milk is in the form of very minute globules, and for that reason the cream does not rise rapidly on the milk. The small globules are an advantage, because the milk is not liable to churn in shipping. Holstein milk has little color.

It is impossible to determine accurately the average production of the breed, but an average of all the cows that have completed a yearly record for the advanced register[1] to April 30, 1919, will give some indication of the breed's production; 4,974 cows averaged 14,783.2 pounds of milk, testing 3.42 per cent butterfat, amounting to 505.71 pounds of fat. The 10 highest producers of the breed whose records have been completed to January 14, 1920, are given in the following table:

Ten highest milk producers among Holsteins.

	Pounds of milk in a year.
1. Tilly Alcartra 123459	33,425.3
2. Lutscke Vale Cornucopia 110505	31,246.9
3. Winnie Korndyke Cornucopia De Kol 101449	31,034.2
4. Raphaella Johanna Aaggie 3d 185125	[2] 30,637.2
5. Zarilda Clothilde 3d De Kol 133840	[2] 30,427.0
6. Queen Piebe Mercedes 154610	30,230.2
7. Lindale Bonnie Pauline 177521	30,024.1
8. Royalton De Kol Violet 86460	29,949.6
9. Laurameka 187954	29,899.0
10. Ignaro Creamcup 102569	29,545.0
Average	30,641.9

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[1] See footnote on page 11.

[2] Strictly official.

Ten highest butterfat producers among Holsteins.

	Pounds of milk.	Pounds of butterfat.
1. Duchess Skylark Ormsby 124514	27,761.7	1,205.09
2. Finderne Pride Johanna Rue 121083	28,403.7	1,176.47
3. Finderne Holingen Fayne 144551	24,612.8	1,116.05
4. Queen Piebe Mercedes 154610	30,230.2	1,111.56
5. Emeretta Korndyke De Kol 189227	28,035.7	1,077.55
6. Ona Button De Kol 115939	26,761.2	1,076.44
7. Maple Crest Pontiac Application 141158	23,421.2	1,075.44
8. Aaggie Acme of Riverside 2d 164467	24,690.0	[2] 1,065.42
9. Laurameka 187954	29,899.0	1,061.27
10. Glen Canary De Kol 2d 227232	25,590.6	1,058.69
Averages	26,940.6	1,102.40

FAMILIES.

The families of Holsteins are very numerous, and it is difficult to determine which are the more important. Probably the following are among the more widely known: Aaggie, Abbekerk, Artis, Beets, Burke, Butter Boy, Carlotta, Clothilde, Colantha, De Kol, Fayne, Gerben, Hartog, Hengerveld, Johanna, Korndyke, Mechthilde, Mercedes, Mutual, Netherland, Ormsby, Pietertje, Pietje, Pontiac, Sarcastic, Segis, Spofford, Vale, and Veeman.

BULLS.

Following is a list of the 10 Holstein bulls having the largest number of daughters with yearly records to April 30, 1919. In making up this list all tests extending over 300 days or more are counted as yearly tests. The average production of the yearly record daughters of each bull is also given.

Ten Holstein bulls with largest number of yearly record daughters.

	Number of yearly record daughters.	Average pounds of milk.	Average pounds of butterfat.
1. Sir Pietertje Ormsby Mercedes, 44931	40	17,305.7	631.27
2. King of the Pontiacs, 39037	39	16,576.1	625.65
3. Sir Johanna Fayne, 42147	26	16,709.6	526.45
4. Dutchland Colantha Sir Inka, 50999	24	15,395.7	529.14
5. King Pontiac Dione, 82505	23	10,970.3	375.48
6. King Pontiac Champion, 53418	22	17,983.4	630.09
7. Johanna De Kol's Lad, 26938	22	15,684.7	515.51
8. Paul Frenesta De Kol, 41206	20	15,139.7	479.96
9. Homestead Girl De Kol Sarcastic Lad, 32558	19	17,875.3	611.04
10. Sir Ormsby Hengerveld De Kol, 31212	17	14,972.2	522.29

ORGANIZATION.

The Holstein-Friesian Association of America is the official organization of the breed in the United States, with headquarters at

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[2] Strictly official.

Brattleboro, Vt., where the secretary resides. The headquarters of the advanced-register work of the association is at Delavan, Wis.

JERSEY.

ORIGIN AND HISTORY.

The island of Jersey, the largest of the Channel Islands, is the native home of the Jersey breed of cattle. Except for immediate slaughter, no cattle have been landed on the island since 1779, so that ever since that time the purity of the breed has been preserved. It seems probable that the foundation stock is the same as the Guernsey, namely, from Brittany and Normandy, in near-by northwestern France. Conditions in Jersey are similar to those in Guernsey. The breeders on the island have developed cattle that, in addition to productive ability, have uniformity of type and natural beauty, while in America the breeders have developed greater size and production, with less refinement of features.

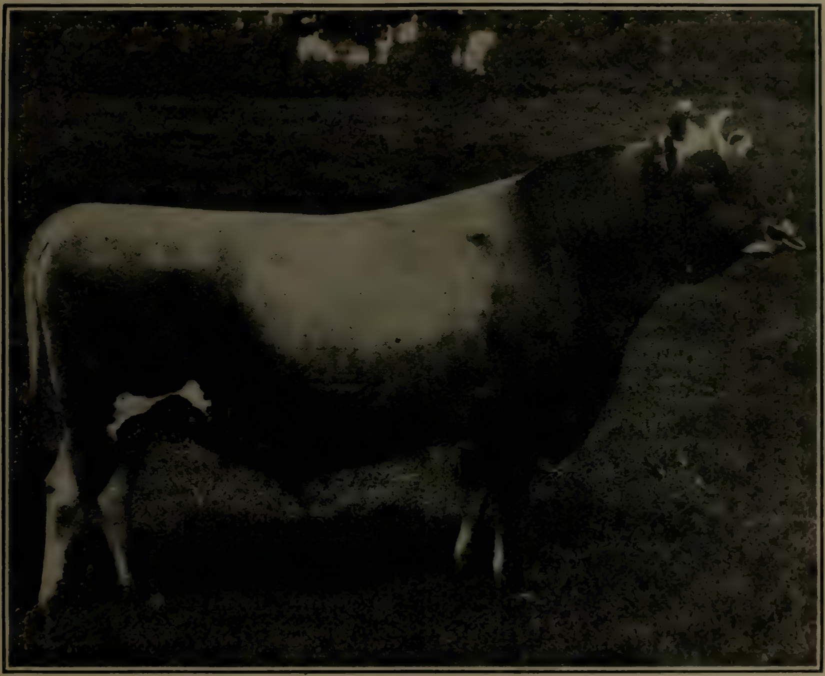

Fig. 16.—Jersey bull, Fauvic's Prince 107961.

IMPORTATIONS AND DISTRIBUTION.

Jerseys were first imported into the United States about the middle of the last century, and since that time importations have been made practically every year. The breed probably has the largest numbers and widest distribution of all the dairy breeds in this country. Large numbers of Jerseys may be found throughout New England, the Middle West, the South, and the Southwest.

CHARACTERISTICS.

Jerseys very considerably in color. The solid-colored animals are preferred by many breeders. Various shades of fawn, squirrel gray, mouse color, and very dark brown are common colors, and in the broken-colored animals white is mixed with these colors.

The muzzles and tongues are usually black or lead colored, and it is very common for animals to have a light or mealy ring around the muzzle. A black switch is also a desirable feature. Next to the Guernsey the Jersey has the yellowest skin secretion of all the dairy breeds. The horns are small, waxy, and frequently tipped with black.

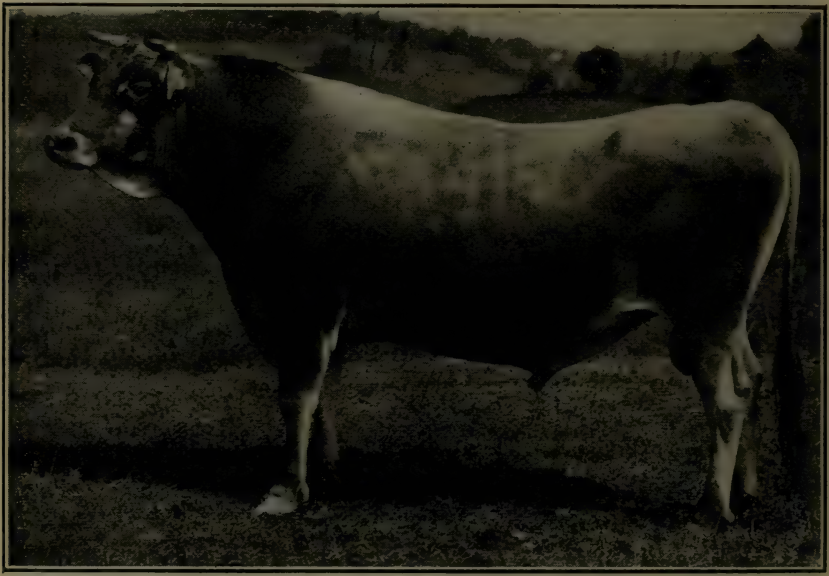

FIG. 17.—Jersey bull, The Imported Jap 75265.

Jerseys have a distinctly nervous disposition and are usually somewhat excitable. Their highly organized nervous system causes them to respond quickly to good treatment and abundant feed. The udders are symmetrical and have sufficiently large teats.

Jerseys are the smallest of the dairy breeds. Mature cows range from 700 to 1,300 pounds in weight (average about 900 pounds); bulls vary from 1,400 to 2,000 pounds (average about 1,500 pounds). Compared with the Guernsey, the Jersey is smaller, and has finer features and more refinement throughout.

The birth weight of calves ranges from 45 to 75 pounds. Animals of the breed mature very early, in this respect excelling all other dairy breeds.

The scale of points for a Jersey cow, adopted May 7, 1913, by the American Jersey Cattle Club, shows the points which the breeders have in mind.

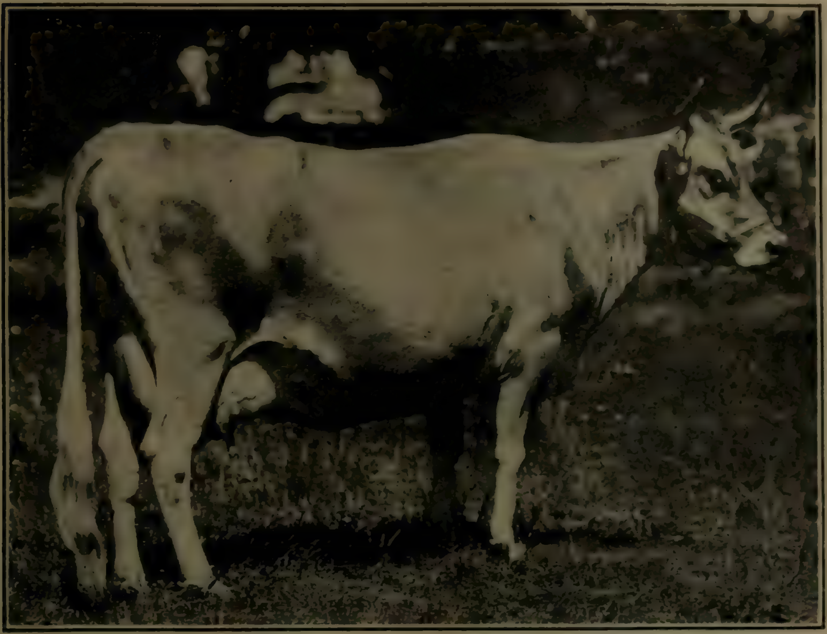

FIG. 18.—Jersey cow, Vive La France 319616.

Scale of points for Jersey cow.

Dairy temperament and constitution:		Counts.
Head		7
Medium size, lean, face dished, broad between eyes; horns medium size, incurving	3	
Eyes full and placid; ears medium size, fine, carried alert; muzzle broad, with wide open nostrils and muscular lips, jaws strong	4	
Neck, thin, rather long, with clean throat, neatly joined to head and shoulders		4
Body		37
Shoulders light, good distance through from point to point, but thin at withers; chest deep and full between and just back of forelegs	5	
Ribs amply sprung and wide apart, giving wedge shape, with deep, large abdomen, firmly held up, with strong muscular development	10	
Back straight and strong, with prominent spinal processes; loins broad and strong	5	

	Counts.	
Dairy temperament and constitution—Continued.		
Body—Continued.		
Rump long to tail setting, and level from hip bones to rump bones	6	
Hip bones high and wide apart	3	
Thighs flat and wide apart, giving ample room for udder	3	
Legs proportionate to size and of fine quality, well apart, with good feet, and not to weave or cross in walking	2	
Hide loose and mellow	2	
Tail thin, long, with good switch, not coarse at setting on	1	

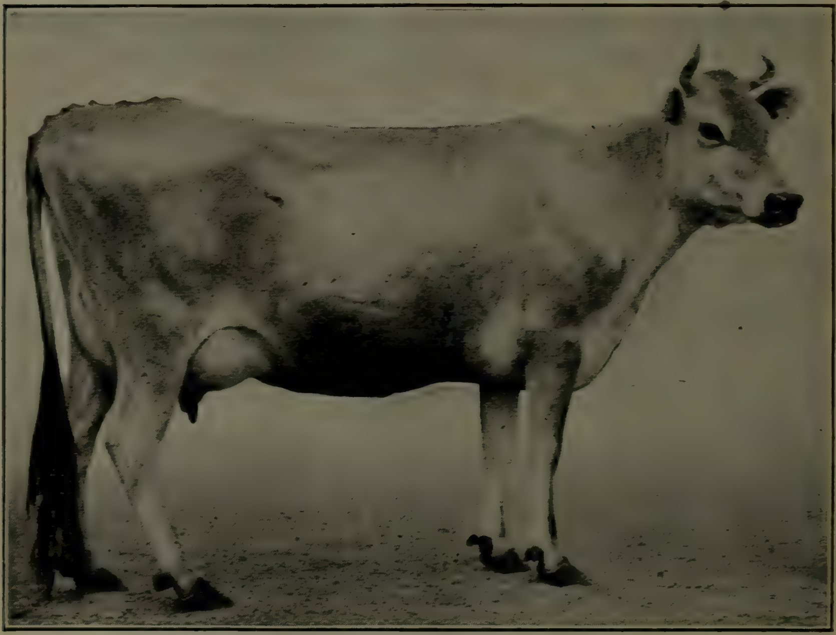

FIG. 19.—Jersey cow, Sophie 19th of Hood Farm 189748.

Mammary development:		
Udder		26
Large size, flexible and not fleshy	6	
Broad, level or spherical, not deeply cut between teats	4	
Fore udder full and well rounded, running well forward of front teats	10	
Rear udder well rounded, and well out and up behind	6	
Teats: Of good and uniform length and size, regularly and squarely placed		8
Milk veins: Large, long, tortuous, and elastic, entering large and numerous orifices		4
Size: Mature cows, 800 to 1,000 pounds		4

General appearance: A symmetrical balancing of all the parts and a proportion of parts to each other, depending on size of animal, with the general appearance of a high-class animal, with capacity for food and productiveness at pail	10
	100

PRODUCTION.

In natural yellow color the milk of Jersey cows ranks next to that of Guernsey cows and is usually slightly richer in butterfat. The large fat globules cause the cream to rise readily upon standing. Jerseys, like Guernseys, are adapted to the production of butterfat.

The average of the 12,258 cows that have completed yearly records for the register of merit [1] up to October 20, 1919, is 7,931 pounds of milk testing 5.35 per cent, making 424 pounds of butterfat. The 10 highest milk and butterfat producers for the breed to February 27, 1920, are given below:

Ten highest milk producers among Jerseys.

	Pounds of milk.
1. Passport 219742	19,694.8
2. Eminent's Bess 209719	18,782.9
3. Lass 40th of Hood Farm 223642	18,661.4
4. Melia's Rilma 249446	18,255.8
5. Rochette's Princess 253833	17,891.1
6. Lass 66th of Hood Farm 271896	17,793.7
7. Successful Queen 278743	17,580.9
8. Sophie 19th of Hood Farm 189748	17,557.7
9. Merry Miss Oonette 288311	17,529.9
10. Majesty's Iris 265701	17,469.7
Average	18,121.8

Ten highest butterfat producers among Jerseys.

	Pounds of milk.	Pounds of butterfat.
1. Plain Mary 268206	15,255.9	1,040.07
2. Vive La France 319616	14,925.7	[2] 1,031.64
3. Sophie's Agnes 296759	16,212.0	[2] 1,000.07
4. Sophie 19th of Hood Farm 189748	17,557.8	999.10
5. Spermfield Owl's Eva 193934	16,457.4	993.30
6. Old Man's Darling 2d 319617	14,631.0	[2] 983.68
7. Eminent's Bess 209719	18,782.9	962.80
8. Oxford's Wexford Spot 259464	16,361.0	958.85
9. Dosoris Park Lily 233783	16,728.1	[2] 957.43
10. Majesty's Iris 265701	17,469.7	955.87
Averages	16,438.2	988.28

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[1] See footnote on page 11.

[2] Carried living calf 6 months or more during test.

FAMILIES.

A considerable number of families have been developed, and it is difficult to determine which are the most prominent, but probably the following are among the best known: Combination, Eminent, Financial King, Gamboge Knight, Golden Glow's Chief, Golden Maid's Prince, Jap-Sayda, Majesty, Noble, Olga Lad, Owl-Interest, Oxford You'll Do, Raleigh, St. Lambert, St. Mawes, and Sophie Tormentor.

BULLS.

The 10 leading Jersey bulls, with the number of their tested daughters and the average of the 10 highest daughters of each, to February 10, 1920, are given below.

Ten best Jersey bulls.

	Average of 10 highest daughters (pounds fat).	Register of merit daughters (year records).
1. Hood Farm Torono 60326[1]	811	72
2. Pogis 99th of Hood Farm 94502[1]	805	53
3. Spermfield Owl 57088[1]	743	45
4. St. Mawes 72053[1]	727	20
5. The Imported Jap 75265[1]	709	30
6. Royal Majesty 79313[1]	704	41
7. Imported Oxford You'll Do 111860[1]	697	53
8. Golden Glow's Chief 61460[1]	696	40
9. Raleigh's Fairy Boy 83767	617	48
10. Fauvic's Prince 107961	573	[2]13

ORGANIZATION.

The American Jersey Cattle Club is the official organization, with headquarters at 324 West Twenty-third Street, New York, N. Y., which is the address of the secretary for both registration and register of merit.

THE PARTS OF A COW.

The accompanying diagram indicates the various parts of a cow that are mentioned in the score cards given in this bulletin, which are used by the respective breed associations in judging dairy cattle.

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[1] American Jersey Cattle Club gold-medal bulls, having three or more daughters each of which made a record exceeding 700 pounds of butterfat, and carried a living calf 155 days or more during the test.

[2] All these made their records with their first calves. Average age at calving, 25 months.

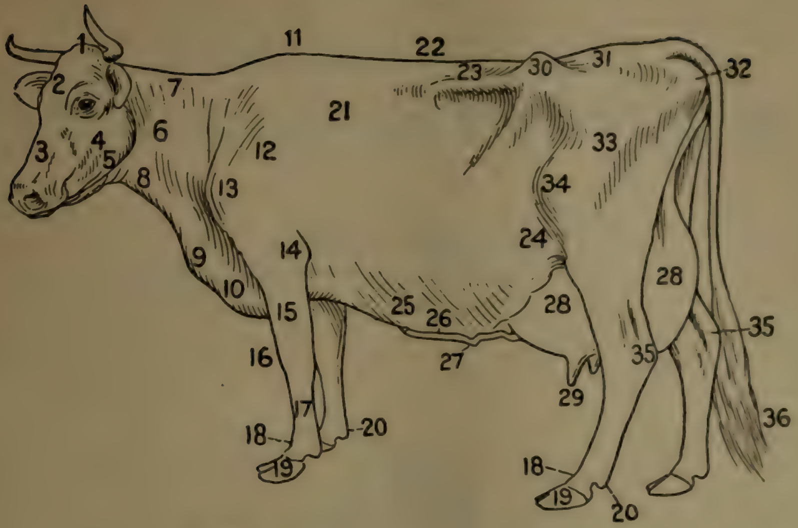

FIG. 20.—Diagram of cow showing points.

1. Poll.
2. Forehead.
3. Bridge of nose.
4. Cheek.
5. Jaw.
6. Neck.
7. Crest of neck.
8. Throat.
9. Dewlap.
10. Brisket.
11. Withers.
12. Shoulder.
13. Point of shoulder.
14. Elbow.
15. Arm or forearm.
16. Knee.
17. Shank.
18. Ankle.
19. Hoof.
20. Fetlock.
21. Crop.
22. Chine.
23. Loin.
24. Flank.
25. Milk well.
26. Milk vein, or mammary vein.
27. Navel.
28. Udder.
29. Teats.
30. Hook, or hook bone.
31. Pelvic arch.
32. Pin bone, thurl, or rump bone.
33. Thigh.
34. Stifle.
35. Hock.
36. Switch or brush of tail.

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Tuberculosis in Live Stock. (Farmers' Bulletin 1069.)

Trend of the Dairy-Cattle Industry in the United States and Other Countries. (Department Circular 7.)

RYE GROWING IN THE SOUTHEASTERN STATES

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FARMERS' BULLETIN 894
UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. October, 1917

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Nov. 29. 1917

RYE should be grown much more widely than at present in many parts of the Southeastern States.

In any consideration of the expansion of the acreage of bread grain and in any encouragement given for the production of home-grown bread in this section it is necessary to consider wheat and rye together. This is because rye can be sown safely on many fields with less risk than wheat. Further, rye can be used as a substitute for wheat as a bread grain by those who are accustomed to it. Rye succeeds on poorer and sandier soils and with less fertilizer than wheat. For these reasons it should be sown in preference to wheat where it has been proved a safer crop.

Rye is also the best grain in most of this section for use as a cover, green-manure, and grazing crop.

Home-grown seed is best. Northern-grown rye is not suitable for sowing in the South.

RYE GROWING IN THE SOUTHEASTERN STATES.

CONTENTS.

	Page.
Increase rye production	3
Rye as a supplement to wheat	3
When to raise rye instead of wheat	3
Varieties of rye	5
Uses of the rye crop	5
Production of the rye crop	6
Harvesting the crop	11
Pests	13

INCREASE RYE PRODUCTION.

IN many parts of the southeastern section of the United States, including the States of Tennessee, North Carolina, Louisiana, Mississippi, Alabama, Georgia, South Carolina, Florida, and the southeastern half of Arkansas, rye should be grown much more widely than at present. Why and where and how this should be done are set forth in the following pages.

RYE AS A SUPPLEMENT TO WHEAT.

Rye is raised less generally now than wheat in this section of the country. But rye is a bread grain used largely by many people of this and other countries. So, in any consideration of the expansion of the acreage of bread grain and in any encouragement given for the production of home-grown bread in this section it is necessary to consider wheat and rye together. For many soils and in many places rye is a safer crop than wheat. For some purposes it is better than wheat.

WHEN TO RAISE RYE INSTEAD OF WHEAT.

Where conditions which make it preferable to raise rye rather than wheat are in effect and under what circumstances rye should be raised in place of wheat are specified below.

(1) Rye will grow on some lands not adapted to wheat. Sandy, exposed, poor, poorly prepared, or acid land will usually yield better crops of rye than of wheat. On large areas of sandy land in this section rye can usually be grown to better advantage than wheat. As rye uses less nitrogen, it can be grown on poorer lands. Rye should be sown on newly cleared timberland and drained marshland, as it is more resistant than wheat to the acid condition of the soil which is likely to exist.

(2) Rye may be sown later in the fall than wheat. If the land can not be prepared in time for wheat, owing to rush of work, seasonal conditions, or because some late-maturing crop is occupying the land, rye may well be sown. Rye will germinate more quickly than wheat and at a lower temperature. It will germinate and grow with the temperature but a few degrees above freezing, when wheat would be practically at a standstill. It can be sown after late-maturing crops are removed, thus furnishing a winter cover and allowing a grain crop to be grown. Since it can be sown late, it distributes labor on farms where wheat is grown, as the wheat can all be sown before rye sowing is begun.

(3) Rye is not so badly injured by insects and diseases as wheat. The Hessian fly seldom injures it badly. The rye crop usually matures before rust becomes severe.

(4) Rye produces a more profitable crop than wheat in at least some parts of this section. The 5-year (1911–1915) average estimated value per acre for rye is greater than for wheat in the States of South Carolina and Alabama. Rye is more profitable than wheat in southern Georgia.[1]

(5) Rye produces a straw more highly valued than that of wheat for bedding horses, stuffing horse collars, for use as packing material, and in paper making. Where there is a demand for the straw for such purposes, as, for instance, near the large cities and near nurseries, and special precaution is taken to preserve it, the straw may be as valuable as the grain. More straw per acre is produced on poor land by rye than by wheat.

(6) Rye will endure more acid in the soil than wheat, and can therefore be used where wheat would require liming. In such cases rye can be produced more cheaply.

(7) Rye uses less nitrogen, pound for pound of crop produced, than wheat, the amount in rye being about four-fifths that in wheat. It can therefore be grown on poorer lands, can be produced with less fertilizer, and does not exhaust the supply of nitrogen so much as wheat.

(8) Rye is generally a better crop for fall, winter, and spring pasture than wheat, as it makes a larger, earlier, and more upright growth than wheat.

(9) For the reasons above cited, rye is generally better for a winter cover and green manure than wheat. It can be sown in cotton at the time of the first or second picking, or in standing corn, and it makes a good growth for plowing under in preparation for other crops. Rye should not be allowed to grow more than knee-high before it is plowed under.

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[1] See Ga. State Col. Agr. Bul. 136.

VARIETIES OF RYE.

In a large part of the cotton belt the Abruzzes (Abruzzi) variety, introduced from Italy by the United States Department of Agriculture in 1900 and 1904, has given remarkably good results. On account of its rapid and vigorous growth even in cold weather it is very valuable for grazing and cover-crop purposes. It also produces good yields of grain—from 15 to 30 bushels per acre under ordinary farming conditions in the cotton belt. In the extreme southern portion of the cotton belt there is an excellent variety known locally as South Georgia rye. Beech Island and Florida Black-Seeded are other names applied to this same or, at least, a very similar variety. When sown in this section it is several days earlier and somewhat taller than the Abruzzes variety, but has yielded hardly as much grain as the Abruzzes rye in comparative tests. In the northern half of this section the North Georgia and Virginia rye gives good yields of grain, but it is not as good as the Abruzzes variety for a pasture and cover crop, as its manner of winter and early spring growth is low and spreading.

USES OF THE RYE CROP.

RYE FOR BREAD.

Rye flour makes a nutritious, wholesome bread, somewhat heavier and darker than that from wheat flour, the color probably being due to the darker gluten it contains. The dough from rye flour often becomes too soft and falls or becomes soggy. To correct this, one-fourth to one-half the quantity of wheat flour is often added. The addition of the wheat flour improves the color and palatability of the bread as well as the working qualities of the dough, rye flour being very sticky and difficult to handle. Wheat and rye flour can, of course, be mixed in any proportion for baking.

RYE GRAIN AS A FEED.

As a feed for hogs, rye grain fed in combination with skimmed milk has about the same value as barley grain so fed. Neither is as good for fattening as corn, but the quality of pork produced is better. Rye shorts is not a satisfactory hog feed. Rye may be fed to work horses from 2 to 4 pounds daily in addition to other grain. Ground rye or rye bran may be fed to milch cows, not more than 3 pounds being used daily.

RYE AS A COVER, GREEN-MANURE, AND GRAZING CROP.

Rye alone or with hairy vetch or crimson, bur, or red clover is frequently sown in the cotton belt with good results as a cover or grazing crop. The crop should be sown early, in order to produce a large amount of fall and winter pasture and to allow a good growth before plowing. A variety making a large early growth, such as the Abruzzes or South Georgia, should be used. Better results are secured by sowing rye with vetch or clover than by sowing it alone. Rye is the best grain to use for this purpose.

When grown as a cover and green-manure crop rye should be plowed under at or before the time it is knee high. If allowed to make more growth it may exhaust the soil moisture and decay slowly in the soil.

Rye being grown for grain will furnish a lot of fall and winter pasture. In this case it should not be pastured too closely or when the ground is wet.

RYE FOR SILAGE.

Rye makes silage of fair quality. It should be cut when the grain is in the late milk stage. It should be cut rather fine in the silage cutter and well trampled in the silo to force as much air as possible out of the hollow stems. It is not as good for milch cows as corn silage but makes a good feed to fill in during the summer between corn crops.

PRODUCTION OF THE RYE CROP.

SOILS ADAPTED TO RYE.

Rye can be grown on almost any of the well-drained soils of the Southeastern States. It is better adapted to the lighter loams and sandy soils than to the heavier clay soils. It yields best and produces the best quality of grain on well-drained loam soils in which there is a good supply of lime. It is not limited to such conditions, however, for it does nearly as well on acid as on nonacid soils and is generally the best grain for sandy soils; also for rough and exposed land. It is much better adapted to sandy and poor soils than wheat, and will endure a greater amount of acidity in the soil than wheat, oats, or barley. It is especially good for drained marshland and for cut-over land being brought under cultivation. Rye should generally be the first crop on such lands. It may often be grown in the sandy soils of the Coastal Plain where other cereals would not succeed. The growing of rye should not be attempted on lands subject to overflow or on which water stands after rains. On lands rich in nitrogen it is likely to lodge.

Rye does not grow as well as wheat in a wet soil. In drier soils it is more winter resistant than wheat. On poor lands rye generally does better than wheat, but on rich lands this condition is reversed.

ROTATIONS.

Rye should be grown as a grain crop only in rotations including legumes and cultivated crops. Local conditions should determine the rotation and the particular crop to be used. It may take the place of wheat, oats, and barley in rotations.

In the southern part of the cotton belt, where the boll weevil is a serious pest, the following rotation is giving good results:

First year.—Cotton. The cotton stalks plowed under early and rye sown.

Second year.—Rye, followed by cowpeas or soy beans, to be cut for hay.

Third year.—Corn and velvet beans. Beans and cornstalks pastured and turned under in early spring for cotton.

Good farm practice under boll-weevil conditions requires that the cotton stalks be plowed under as soon as the bolls are all open and picked, care being taken to cover the stalks completely in order to destroy the insects. The land should then be gone over with a roller and the rye sown with a disk drill. Harrowing is not advisable, as it unearths the buried stalks.

When velvet beans are grown with corn, which is the common practice in much of the southern half of the cotton belt, rye can not be sown in the standing corn; neither can the crop be removed in time for fall seeding. It is necessary, then, that rye follow some other crop than corn. Fortunately, better yields of rye can be expected following cotton than after corn.

For the northern part of the cotton belt the rotation may be as follows:

(1) Cotton, with crimson clover sown at the last cultivation and plowed under the following spring.

(2) Corn, with cowpeas sown between the rows at the last cultivation, plowed under for rye.

(3) Rye, followed by cowpeas, followed by rye to be turned under in the spring. The cowpeas following the rye crop may be cut for hay, or they may be disked in or plowed under as green manure.

In tobacco-growing sections rye may follow tobacco in the rotation.

One advantage of the rye crop is that it can be used to fill gaps between other crops. It can be sown early or late in the fall, on land either rough or well prepared, and it will practically always make a good growth, conserving fertility and preventing washing during the winter. The farmer can then decide in the spring whether to use it as pasture, as a soiling crop, as a green-manure crop to plow under, or as a straw and grain crop.

It is good farm practice in the northern part of the Southeastern States to sow rye where possible, following a cultivated crop. An excellent seed bed can then be made as soon as the cultivated crop is off the ground by using a disk harrow, followed by a spike-tooth harrow. The grain is thus seeded with a minimum of labor. If sown early, grass and clover seed can be put in at the same time.

VOLUNTEER RYE.

Rye will often reseed itself for several years in fields where conditions are favorable after it is sown. This volunteer rye is objectionable if wheat follows, as the grains of rye and wheat can not be separated by cleaning machinery. If rye is present in wheat used for flour making in amounts as high as 2 per cent or more, it lowers the quality of the bread.[1] On this account millers and grain dealers frequently make a considerable discount in the price of wheat containing rye. Special efforts should be made, therefore, to prevent the mixing of rye with wheat. For this reason wheat should not follow in the rotation rye that has been grown for grain. Sowing mixed seed should be avoided, and volunteer rye should not be allowed to grow in wheat fields.

PREPARATION OF THE SEED BED.

When rye follows a cultivated crop, such as corn, tobacco, or cowpeas cut for hay that is removed sufficiently early, the soil can usually be prepared for seeding by use of a disk and ordinary harrow. As soon as the crop is harvested the land should be gone over with the disk to prevent the growth of grass and weeds. A second disking, followed by harrowing, is given just before the grain is sown. A better seed bed can be prepared in this way than by plowing, and it takes much less time and work. If weeds are plentiful, plowing 3 or 4 inches deep may be necessary. Harrowing with an ordinary harrow should follow the plowing. When rye follows cotton the stalks should be plowed under as soon as the bolls are all open and picked. Plowing in this case should be deep enough to bury the stalks completely in order to destroy the boll weevil. The land should then be firmed with a roller and the rye sown with a disk drill. Disking or harrowing is not advisable, as it unearths the buried stalks.

When rye follows other than a cultivated crop, the seed bed should be prepared by plowing the land to a depth of 6 or 7 inches several weeks before seeding. It should then be harrowed at once and afterwards worked down with harrow, disk, drag, or roller in such a manner as to kill all weeds that start to grow after rains and to settle the subsoil and keep the topsoil well broken up. When it is necessary to plow just before seeding, as when a catch crop of cowpeas is plowed under, the soil should be compacted by rolling and harrowing several times before seeding. In any case, when it is time to sow the grain a fine, mellow seed bed should be prepared, by using the harrow or other tools if necessary.

Rye may be sown broadcast in cotton, corn, or other standing crops without previous soil preparation, but it should be covered after sowing. A broad sweep, double shovel, or cultivator is a suitable implement for covering, passing once between every two rows. Cotton or corn is not injured by this treatment. A 1-horse, 3 to 5 hole drill is much better and will readily pass between the rows of the standing crops.

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[1] For further information on the effect of rye flour in wheat flour, see U. S. Department of Agriculture Bulletin No. 328, entitled "Milling and baking tests of wheat containing admixtures of rye, corn cockle, kinghead, and vetch," by R. C. Miller.

FERTILIZERS FOR RYE.

Although rye will grow on very poor soils, large yields of forage or grain may be expected only on soil that is of good fertility. Rye for grain production should not be sown on very rich land; neither should large quantities of fertilizers containing nitrogen be applied to the crop. Stable manure is the best fertilizer for general use with rye, but phosphorus should generally be applied in connection with it. The addition of 40 to 50 pounds of acid phosphate or rock phosphate to each ton of manure and the application of 2 to 4 tons per acre of this combination should be generally profitable on poor land. Larger applications may be made on very poor land.

When commercial fertilizers only are available, an application of acid phosphate, 16 per cent goods if possible, at the rate of 150 to 250 pounds per acre when the crop is sown is generally advisable. A small amount of cottonseed meal may also be used to supply nitrogen, this being applied two or three weeks before seeding or at the time of seeding, but not in contact with the seed. Nitrate of soda may often be used to good advantage. This should be applied with discretion, however, as an excess of nitrate will result in serious loss from lodging. Rye requires considerably less nitrogen for good results than wheat. On the poorest soils, 25 pounds of nitrate of soda may be applied at seeding time and 50 to 75 pounds used as a top-dressing after growth starts in the spring. On richer soils the spring application is generally sufficient. On soils that are naturally rich, or that have been fertilized for preceding crops, fertilizers for the rye crop may be omitted.

In place of these applications, 150 to 250 pounds of a 10–3–3 fertilizer (that is, a fertilizer containing 10 per cent of phosphorus and 3 per cent each of nitrogen and potassium[1]) may be used. If some other fertilizer of about the same composition is more readily obtainable, it may be used, the principal requirement being a comparatively large amount of phosphorus.

Where rye is grown for pasture, for soiling purposes, or for the straw, larger applications of nitrogenous and other fertilizers may be made. If the land is not especially fertile, six to eight loads of barnyard manure should be applied after plowing and harrowed in thoroughly. Commercial fertilizer rich in phosphorus should be used if manure is not available.

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[1] It is not advisable to pay the present (1917) prices for potash for the rye crop. This recommendation is for normal conditions.

PREPARATION OF THE SEED.

Seed rye should be thoroughly cleaned and all immature kernels removed before it is sown. As rye loses its germinating power much more rapidly and readily than other cereals, all seed should be tested for germination before sowing and the rate of seeding regulated accordingly.

To make a germination test, several lots of 100 grains each should be counted out and placed between clean blotters or Canton flannel or in sand, where they must be kept moist and at a temperature of about 70° F. for several days. The number of seeds which show strong sprouts should then be counted. Seed that is weak in vitality or low in germination should be discarded or sown at a higher rate per acre than that commonly employed.

TIME OF SEEDING.

The time of seeding rye depends upon the use to be made of the crop. When intended for grain production it should be sown from about October 15 in the northernmost part of the Southeastern States to the latter half of November or later in the southern section.

Rye may be sown a week or two weeks later than wheat unless wheat sowing is unusually delayed, as rye germinates more quickly and makes a more rapid early growth, especially if the weather is cool.

If intended as a pasture crop, as a cover and green-manure crop, or as a combination of these, rye should be sown from two weeks to a month earlier than if it is to be used for grain.

In the northern part of the Southeastern States it should be sown for pasture, cover crop, and green manure between September 15 and October 15, and about two weeks later in the southern part. A satisfactory time to sow in the cotton fields is just after the first or second picking, about the middle of September.

It is desirable to sow rye sufficiently early for the plant to become well established before winter begins. Where a deep root system is formed early the plant starts growth earlier in the spring. Rye can be sown with success on fertile land in a good seed bed later than it can on poor land in a poor seed bed.

METHOD OF SEEDING.

Rye is best sown in drills 6 to 8 inches apart, using a regular grain drill and covering the seed one-half inch to 2 inches deep, depending on the texture and moisture content of the soil. Less seed and labor are required, and a more even and uniform stand is thus secured than by any other method. When a drill is not available, rye may be sown broadcast by hand or with a broadcast seeder and covered by harrowing. The person sowing the seed may save labor and can sow more evenly and rapidly by standing or sitting on the rear end of a wagon as it is drawn slowly back and forth across the field. When sown in a standing crop, such as corn or cotton, rye may be sown broadcast and covered with a plow, sweep, or 1-horse cultivator, passing once between rows, or, still better, with a drill made for sowing between rows of standing crops. Some farmers when sowing in standing corn or cotton rows sow the grain from horseback.

RATE OF SEEDING.

The usual rate of seeding rye in the Southeastern States is from 3 to 4 pecks per acre. Too thick seeding upon fairly fertile soil will produce soft culms, which are likely to lodge or crinkle. On the sandy loam soil in the central cotton belt sowing 2 pecks of Abruzzes rye on good soil and 3 pecks on light soil has given the best yields of grain from November 15 seeding. For later sowings more seed is required.

When intended for soiling purposes, more seed should be sown per acre than when the rye is intended for grain. Two bushels per acre is the usual seeding.

HARVESTING THE CROP.

DATE OF RIPENING.

At the northern boundary of Florida rye ripens about May 10. At the northern boundary of Georgia it ripens about June 1. These figures indicate that as one passes northward from Florida rye ripens approximately one day later for each 15 miles traveled, allowance being necessary, however, for increased elevation.

Rye is generally a few days earlier than wheat in ripening. Rye cutting may begin a few days before it is fully ripe, or while there is still a slight green tinge about the plant. This is especially desirable when the straw is to be marketed, as a bright, heavier straw results.

CUTTING.

Rye is cut and bound like wheat. The straw of rye commonly grows to a height of 5 feet and frequently reaches 6 feet. On fertile soil it may reach or even exceed 7 feet in height. On account of this long, slender growth it is likely to be more or less lodged and tangled at harvest time, especially on rich soils. It is then extremely difficult to harvest with a self-binder. Even when the grain is standing, it is difficult to cut a heavy crop in this way, as many machines do not have sufficient capacity for such long straw. If there is no special object in saving the straw, the cutter bar may often be raised sufficiently to allow the machine to handle the crop. If the rye is grown principally for the straw, however, a tall crop must often be cut with a self-rake reaper and bound by hand. This requires about four extra men and is necessarily very expensive. The old-fashioned cradle may also be used in cutting heavy or lodged and tangled rye.

SHOCKING, STORING, AND STACKING.

Rye is generally shocked in the same manner as wheat and other cereals. Special care should be taken to have the shocks well built and capped, so that as much as possible of both grain and straw will be protected from the weather. As soon as the crop is well cured in the shock, which will ordinarily be in about 10 days after cutting, it should be stacked or put under cover until thrashing time. As the straw is often quite as valuable as the grain, and as its value depends largely on its condition, care in handling between cutting and thrashing is usually well repaid.

THRASHING.

When no special use is to be made of the straw, the method of thrashing rye is the same as that for wheat and other grains. When rye straw is intended for a particular purpose, such as packing material for nursery stock or stuffing for horse collars, an ordinary thrashing machine can not be used, as it breaks and twists the straw too much. The flail was long used for thrashing rye and may still be utilized, but special machines are in use by means of which the grain can be removed without injuring the appearance of the straw.

These machines, sometimes known as "beaters," differ from the ordinary grain separator in that the cylinder is from 5 to 6 feet long and the straw is fed into the cylinder lying parallel to its axis rather than at right angles, as is usually the case. There is no concave, and the cylinder contains no teeth. It is made up of bars with shallow corrugations diagonally across the face, the corrugations on adjacent bars being at different angles. The straw from the unbound bundles is carried over the cylinder, which is run at very high speed, and the grain is beaten out between the cylinder and the top of the machine. The straw is then dropped upon a long inclined shaker, which consists of a number of bars with teeth. These teeth push the straw to the rear of the machine, where it is tied in small bundles by means of a binding attachment similar to those used on binders.

YIELD OF RYE.

The 10-year (1907–1916) average yields in bushels per acre of rye for several of the Southeastern States have been as follows: Tennessee, 11.3; North Carolina, 9.9; Alabama, 11.2; Georgia, 9.3; South Carolina, 10.1.

Comparative yields of wheat and rye obtained at several points in Georgia in cooperative tests made by the Bureau of Plant Industry and the Georgia State College of Agriculture are contained in Georgia State Agricultural College Bulletin 136.

The legal weight per bushel of rye in each of the States of this section is 56 pounds.

PESTS.

WILD ONION, OR GARLIC, IN RYE.

Wild onion, or garlic, is a pest in many of the Southeastern States. The onion bulblets are about the same size and shape as rye grains and reach maturity at the same time. They are therefore harvested with the crop and can be separated from the thrashed grain only with much difficulty. When such rye is sold it is docked severely, often 15 cents or more a bushel. A small percentage of onion bulblets will spoil flour made from the grain, giving the bread a disagreeable odor and flavor. If only a few onions are present in the growing crop, they should be dug out and burned. Land badly infested should, if possible, be used for some other crop than small grains. Rye, however, lends itself to the more or less complete eradication of the wild onion, as the crop may be sown late on land plowed and prepared just before planting.[1]

OTHER WEEDS IN RYE.

Cockle, chess or cheat, and peppergrass plants may be present in rye fields and their seeds in the thrashed grain. Good farming methods will largely eliminate them from farms. This task is much more easy if the seeds are not added with the grain sown.

INSECT ENEMIES OF RYE.

Rye has no special insect enemies, but is attacked more or less by the same insects, such as chinch bugs, grasshoppers, and army worms, which feed on the other small-grain crops. The Hessian fly does not affect rye as badly as wheat. The granary weevil and the Angoumois grain moth in both the larval (worm) and adult stages live within the stored kernels and may be very destructive.

The most effective means of combating the Hessian fly is by late sowing. Where this insect is very troublesome, rye may be sown in place of wheat, since the insect does not injure it so badly and since rye can be sown with success later than wheat. Detailed information concerning the Hessian fly and methods of combating it are contained in Farmers' Bulletins 640 and 835 and other publications of the United States Department of Agriculture.

Insects present in grain stored in bins and barrels may be destroyed by the use of liquid carbon disulphid.

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[1] For further information on methods of eradicating wild onion, see Farmers' Bulletin 610, entitled "Wild onion: Methods of eradication," by H. R. Cox.

Place the grain in air-tight bins holding from 30 to 40 bushels. Place 1 pound of carbon disulphide in a shallow vessel on top of the grain and cover the top of the bin as tightly as possible. The liquid readily vaporizes and the fumes being heavier than air pass down through the grain, destroying all insects. This method is effective only when the temperature is above 60° F.[1]

RYE DISEASES.

Rye is subject to attacks of both stem and leaf rust. These diseases manifest themselves by the appearance of orange-yellow to reddish brown pustules, which in the one case affect the leaves and in the other the leaves and stems of the attacked plant. The crop is seldom badly injured by these diseases. The flag smut of rye sometimes occurs on the flag, or uppermost leaf, though usually it affects the neck, causing this portion of the stem to split and break over. Losses of as much as 3 to 5 per cent are sometimes caused by this smut. The occurrence of loose smut of rye has been reported four times in three years and is of no economic importance.

A disease called anthracnose is prevalent in some parts of the rye-growing area. The attacks of this disease are shown by the premature dying of those portions of the heads above the point of its attack, resulting in the almost total loss of the grain in these dead portions. The disease also attacks the roots and lower portions of the stems, resulting in a blackened appearance of the attacked parts and in the loss of vigor of the diseased plant, which therefore produces only shriveled grains. Treatment of the seed with formaldehyde (1 part of formaldehyde to 50 parts of water), as is common for oat and wheat diseases, is a preventive.

A serious and destructive disease of rye is ergot. In this, one or more kernels of the head are replaced by a horny violet or purplish structure, usually somewhat larger than the kernel. Where ergot is present rye should not follow rye in the rotation, and seed free from ergot should be sown. It is dangerous to feed rye containing ergot to live stock.

Ergot may be completely separated from rye by passing the grain through a 20 per cent solution of common salt, in which the ergot will float and the rye will sink. This treatment does not affect germination, and the rye can be sown as soon as the excess water has drained off.

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[1] Detailed information concerning these pests in stored grain and complete directions for destroying them are contained in Farmers' Bulletin 799, entitled "Carbon Disulphid as an Insecticide."

OTHER PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE OF INTEREST IN CONNECTION WITH THIS BULLETIN.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Oats: Growing the Crop. (Farmers' Bulletin 424.)
Winter Oats for the South. (Farmers' Bulletin 436.)
Barley: Growing the Crop. (Farmers' Bulletin 443.)
The Smuts of Wheat, Oats, Barley, and Corn. (Farmers' Bulletin 507.)
Winter Barley. (Farmers' Bulletin 518.)
The Culture of Winter Wheat in the Eastern United States. (Farmers' Bulletin 596.)
Winter-Wheat Varieties for the Eastern United States. (Farmers' Bulletin 616.)
The Hessian Fly. (Farmers' Bulletin 640.)
Growing Hard Spring Wheat. (Farmers' Bulletin 678.)
Varieties of Hard Spring Wheat. (Farmers' Bulletin 680.)
Marquis Wheat. (Farmers' Bulletin 732.)
Culture of Rye in the Eastern Half of the United States. (Farmers' Bulletin 756.)
Shallu, or "Egyptian Wheat." (Farmers' Bulletin 827.)
How to Detect Outbreaks of Insects and Save the Grain Crops. (Farmers' Bulletin 835.)
Wheat Growing in the Southeastern States. (Farmers' Bulletin 885.)
Oats in the Great Plains Area. (Department Bulletin 218.)
Barley in the Great Plains Area. (Department Bulletin 222.)
Alaska and Stoner, or "Miracle," Wheats; Two Varieties Much Misrepresented. (Department Bulletin 357.)
Experiments with Marquis Wheat. (Department Bulletin 400.)
Improvement of Ghirka Spring Wheat in Yield and Quality. (Department Bulletin 450.)
Hard Wheats Winning Their Way. (Separate 649 from Yearbook 1914.)
Rye in the Cotton Belt. (Secretary's Special, December 2, 1914.)
Winter Wheat in the Cotton Belt. (Secretary's Special, November 21, 1914.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Sixty-Day and Kherson Oats. (Farmers' Bulletin 395.) Price, 5 cents.
Oats, Distribution and Uses. (Farmers' Bulletin 420.) Price, 5 cents.
Barley Culture in the Southern States. (Farmers' Bulletin 427.) Price, 5 cents.
Durum Wheat. (Farmers' Bulletin 534.) Price, 5 cents.
Experiments with Wheat, Oats, and Barley in South Dakota. (Department Bulletin 39.) Price, 10 cents.
Spring Wheat in the Great Plains Area. (Department Bulletin 214.) Price, 10 cents.
Milling and Baking Tests of Wheat Containing Admixtures of Rye, Corn Cockle, Kinghead, and Vetch. (Department Bulletin 328.) Price, 10 cents.
Some Insects Attacking the Stems of Growing Wheat, Rye, Barley, and Oats, with Methods of Prevention and Suppression. (Entomology Bulletin 42.) Price, 5 cents.
The Rye Crop of the United States. (Statistical Bulletin 60.) Price, 10 cents.
Successful Wheat Growing in Semiarid Districts. (Separate 195 from Yearbook 1900.) Price, 5 cents.
Influence of Rye on the Price of Wheat. (Separate 209 from Yearbook 1900.) Price, 5 cents.

The Commercial Status of Durum Wheat. (Bureau of Plant Industry Bulletin 70.) Price, 10 cents.
Cultivation of Wheat in Permanent Alfalfa Fields. (Bureau of Plant Industry Bulletin 72, part 1.) Price, 5 cents.
Improving the Quality of Wheat. (Bureau of Plant Industry Bulletin 78.) Price, 10 cents.
Garlicky Wheat. (Bureau of Plant Industry Bulletin 100, part 3). Price, 5 cents.
The Loose Smuts of Barley and Wheat. (Bureau of Plant Industry Bulletin 152.) Price, 15 cents.
Experiments in Wheat Breeding. (Bureau of Plant Industry Bulletin 269.) Price, 15 cents.
Handling Wheat from Field to Mill. (Bureau of Plant Industry Circular 68.) Price, 5 cents.
Winter Wheat in Western South Dakota. (Bureau of Plant Industry Circular 79.) Price, 5 cents.

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GROWING WINTER WHEAT ON THE GREAT PLAINS

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FARMERS' BULLETIN 895

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. September, 1917

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LIMITED RAINFALL is the controlling factor in crop production in the Great Plains. The average yields of a series of years can be foretold from the records of past years; but, because the rainfall is fluctuating in amount and uncertain in distribution, the yields of a single year can not be foretold with any certainty. The chances of success are, however, much better when the soil is wet to a considerable depth at seeding time than they are when the soil contains little or no available water at that time.

The relation between the amount of water in the soil at seeding time and the yield is much closer with winter wheat than with other crops. This crop should, therefore, be seeded on the best-prepared land and that in which the greatest amount of water is stored. Except in the southern section, the response of winter wheat to summer tillage is greater than that of any other crop. Summer-tilled land should be seeded to winter wheat wherever this crop can be grown. The growth of corn is one of the best preparations for winter wheat, especially north of Kansas.

With increase in the length of season and the time between harvest and seeding, there is an increase in the value of early preparation for winter wheat. In the northern section the crop can be replaced with spring wheat without serious loss. In the central section, winter wheat has a greater advantage over spring wheat and can not be replaced by the latter without serious loss. In the southern section, winter wheat is less certain and less productive than farther north and can not be replaced by spring wheat. It is, however, profitably raised under favorable conditions of soil, season, and preparation. In this section particularly it should be recognized that the chances of producing a crop are low when it is seeded on land that does not contain water enough in storage to wet the soil to a depth of 3 feet.

GROWING WINTER WHEAT ON THE GREAT PLAINS.

CONTENTS.

Page.
Farming conditions on the Great Plains 3
Varieties of winter wheat 4
Rate of seeding 4
Date of seeding 5
Adaptation, relative value, and cultural methods 5
General considerations 11

FARMING CONDITIONS ON THE GREAT PLAINS.

THE SOILS of the Plains are generally rich. Fertilizers are never used. The broad level or rolling fields of the prairie lend themselves to an extensive agriculture in which large machinery can be used to advantage and a minimum of man labor be made to cover effectively a maximum acreage. Winter wheat is naturally adapted to such an agriculture.

The results of the experiments of the Department of Agriculture show that the most profitable and greatest returns per unit of labor are obtained by expending the labor on as large an acreage as can be efficiently covered rather than by attempting to obtain increased yields from a given acreage by concentrating a greater amount of labor upon it. The factor that determines and controls the agriculture of the region is the limited rainfall and its uncertain distribution. The uncertainty of the distribution of the rainfall rather than the total average quantity received is the factor that makes crop production hazardous. Over the greater portion of the Great Plains the average rainfall is sufficient to insure the production of crops, but the rainfall in any given year may be either above or below the average. When above the average the production of good crops is assured unless the distribution of the rainfall is very unfavorable. The crop may be destroyed by hail, but hailstorms are of local occurrence and do not affect general conditions. When the rainfall is much below normal it may not be sufficient to produce a crop. Under such conditions the greater the amount of water in storage in the soil

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NOTE.—This bulletin is intended to answer the requests for information on the production of winter wheat on the Great Plains under dry-farming conditions that arise from the stimulus of a present and prospective price much higher than that under which the agriculture of the section has been developed and from the campaign for a large increase in the crop to meet the necessities of war conditions.

at seeding time the greater is the chance of making a crop. Water so stored is of advantage in supplementing the rainfall, but nowhere on the Great Plains can much more than a crop of straw be produced from the water in the soil alone.

From the results under known conditions in the past years the average results of a series of years in any section can be forecast with a reasonable degree of certainty, but nowhere on the Plains can the results of a single season be forecast. Knowing, though, that the greater the amount of water in the soil at seeding time the less dependent is the crop on the rain that falls while it is growing, it is possible to make at seeding time some forecast of the chances of success. Particularly is this true of winter wheat, which shows a closer relation between the yield and the water content of the soil at seeding time than any other crop. In a normal soil under dry-farming conditions winter wheat can use water from a depth of 6 or more feet. These soils are seldom wet to this depth when cropped every year and not usually beyond it when fallowed. The depth to which the soil is wet can usually be told easily by inspection, the break between wet and dry soil being very sharp. A good guide to practice is to sow a large acreage when the soil at seeding time is wet to as great a depth as 3 feet. This means that the conditions are favorable for germination and growth and that the chances for a crop are good, even though the winter and spring rainfall may be below the average. On the other hand, seeding in a dry soil means that the rainfall and other climatic conditions from that time forward must be better than the average if a crop is to be produced.

Only an exceptionally wet winter and spring could have produced a good winter-wheat crop on the Great Plains in 1917. There was no water in storage when it was seeded. The winter and spring being dry it had no opportunity to overcome this handicap.

VARIETIES OF WINTER WHEAT.

Two named varieties of winter wheat are of such superior merit in hardiness, yield, and quality that they are grown almost exclusively throughout the Great Plains. They are both of the same type and general appearance and belong to the hard red winter or Crimean group of wheats. The Turkey Red is the older of these varieties. Kharkof, a later importation of the same type, usually has been found slightly superior to the older variety in hardiness and yield and is now quite generally grown.

RATE OF SEEDING.

The relation between stand and yield is determined by so many varying conditions of season and the stand itself is affected by so many things besides the rate of seeding that no one best rate can be established. Within a considerable range of rate the average yield is not greatly affected. If the ground is free from weeds a thick stand will generally be shorter and earlier and suffer sooner from drought than a thin stand. A thick stand, however, discourages the growth of weeds.

On a poor seed bed, in sections where winter injury is usually severe or when seeding is so late that there is time for but little fall growth, more seed should be sown than under other conditions. The usual range is from 30 to 60 pounds per acre. Good crops have been raised from seedings as light as 15 pounds and as heavy as 2 bushels per acre. Probably the greater bulk of the crop is seeded at the rate of 40 to 50 pounds per acre.

DATE OF SEEDING.

In the northern section of the Great Plains there is no danger of seeding winter wheat too early in the fall. The earliest sown wheat does not go beyond the rosette stage in the fall, and there is no growth during the winter. Wheat sown early enough to become well stooled in the fall survives the winter better and matures earlier than that sown later. In the northern and western portions of this section the best time is between August 15 and September 15, and in the southern portion of this section between September 1 and September 20.

In the central section wheat is seldom seeded earlier than September 15. Seeding may be continued until after October 15 but to sow after that date is considered undesirable. Wheat is sometimes sown late in this section to escape insect injury. Where there is danger of blowing during the winter and spring, early seeding is of advantage in making growth enough to protect the soil. But a heavy fall and winter growth makes an inefficient use of soil moisture and may contribute later to damage from drought.

In the southern section, the earliest date of seeding is the same as in the central, but the latest date may be much later. The usual time is from October 1 to October 15. Early seeding affords pasture and protects the soil from blowing, but late seeding tends to the conservation of water for use by the crop in the spring and avoids fall injury by insects, which is an important consideration in some sections.

ADAPTATION, RELATIVE VALUE, AND CULTURAL METHODS.

While certain cultural directions may be generalized either for the area as a whole or for considerable sections of it, such questions as the adaptation of winter wheat, its reliability and value in comparison with other crops, and its response to cultural methods may well be considered by States. With the wide range of conditions to be encountered within most of the States, even this method of consideration requires more generalization than is desirable in giving information that may be acted upon with assurance and profit.

MONTANA.

Only that portion of the State that lies east of the mountains is here considered. The western portion of this Plains area is well adapted to winter wheat. In the eastern portion of the area the winter survival of winter wheat becomes less and less until at the North Dakota line it can not be raised at all. As in any other section, winterkilling may be experienced in any part of the State. When this occurs, the loss is not so serious, as the land is prepared and can be reseeded with spring wheat. On the average, there is little difference in the yield of the two crops on land that raised a crop the preceding year. Land that has been summer fallowed should be seeded to winter wheat, as the relative response of winter wheat to fallow is much greater than that of spring wheat or of any other crop.

The lateness of harvest and the shortness of the season which makes it necessary to seed early leaves little or no choice as to time of plowing, nor is there much, if any, difference shown as a result of difference in depth of plowing. Indeed, both winterkilling and soil blowing are often guarded against by seeding in grain stubble without plowing. As this practice is apt to encourage the growth of weeds, it is to be advised only on clean land, and preferably on land that has either been summer fallowed or spring plowed for the preceding crop. In the Judith Basin the yield on summer-tilled land has not been enough greater than that on land producing a crop each year to justify the practice, but at Huntley, where the summer conditions are more severe, the yield has been nearly doubled. At both stations the second highest yield has been on disked corn ground. On account of its lower cost, this method of preparation has been the most profitable from the standpoint of the wheat alone. In addition to this, the corn in the Judith Basin has produced an average yield of about 2½ tons of fodder per acre and at Huntley of about 20 bushels of corn and 1¼ tons of stover per acre. Figured at normal prices of crops and labor, the most profitable combination of crops at any point on the Great Plains has been that of corn and winter wheat on disked corn ground at Huntley.

At the Judith Basin Experiment Station the average yield for the eight years, 1909 to 1916, inclusive, has been 24 bushels per acre. The only total failure was by the winterkilling of the crop of 1916. At Huntley the average yield for the 4-year period, 1913 to 1916, was 31.4 bushels, with no failures. These average yields are made up from about an equal division of the poorer and the better yielding methods. The good farmer who is well equipped and able to handle his work in season should be able to equal them.

NORTH DAKOTA.

Winter wheat does not survive the winter and is not raised in North Dakota. The fall season is spent in preparation, chiefly plowing, for spring crops, of which wheat occupies the largest acreage.

SOUTH DAKOTA.

The only sections of the State in which winter wheat is now grown to any considerable extent are in the southeastern portion and in the Black Hills section. Winter wheat probably should be grown more extensively than it is. Special effort should be made to provide winter protection either by sowing in standing corn or in small-grain stubble that is clean and free from weeds. In the western portion of the State its winter survival is better. Here the chief troubles are likely to be a lack of moisture in the surface soil to germinate the seed and establish a stand in the fall and damage from drought during the growing season. At Belle Fourche the 8-year average yield of 23.1 bushels per acre from summer tillage has been nearly twice that from land producing a crop each year. Disked corn ground has not been under trial. At Ardmore the 4-year average yield from summer tillage was about the same as at Belle Fourche, but the comparative yields from other methods have been better. At both stations these very satisfactory average yields have been obtained from an almost equal division between years of near or complete failure and years of excessively high yields.

On the heavy clay soil of this section of the State the time of fall plowing is of much less importance than is the condition of the land when it is plowed. Land that is plowed dry is rough and lumpy and does not work into a good seed bed until it weathers down during the winter. On such land both the stand and the winter survival is likely to be poorer than on land plowed when in a friable condition.

NEBRASKA.

In western Nebraska there are two outstanding methods of excellence for the production of winter wheat. These are summer tillage and disked corn ground. At North Platte the average yield of winter wheat on summer-tilled land for 10 years was 30.6 bushels per acre, and that on early fall-plowed wheat stubble 15.3 bushels. During the five years it has been under trial the yield on disked corn ground has been fully equal to that on summer-tilled land. The 5-year average yield at the Scottsbluff station on summer-tilled land was 20.6 bushels; on disked corn ground, 15.4 bushels; on early fall-plowed wheat stubble, 9.1 bushels, and on late fall-plowed wheat stubble, 5.4 bushels per acre. The use of corn instead of summer tillage as a preparation for winter wheat has the advantage of producing not only a profit from the corn crop but of adding to the feedstuff produced, thus making it possible to keep stock as well as to grow wheat.

WYOMING.

The results of the experiments at the Huntley, Mont., Belle Fourche, S. Dak., Ardmore, S. Dak., and Scottsbluff, Nebr., Field Stations are applicable in part to Wyoming. The results of the Archer, Wyo., Field Station apply to the higher altitudes in the southeastern portion of the State.

Winterkilling becomes increasingly worse with increase of altitude and with decrease of precipitation. At high altitudes a crop after surviving the winter may be seriously damaged by spring freezes. If the crop survives, winter wheat has a general advantage of yield over spring wheat, partly due in this section to its earliness, enabling it to avoid summer drought. Summer fallow has the advantage of providing some protection from drought, but on account of the bare smooth surface is more liable to winterkilling and spring blowing than other preparations. Both the winter survival and resistance to drought following corn or other cultivated crops are so good that these are among the best preparations for winter wheat. Perhaps the best crops are grown the first year after breaking prairie sod. Sufficient time should elapse between breaking and seeding to allow the storage of several inches of water in the soil. This is generally accomplished by breaking in the spring, letting the ground lie bare during the summer, and seeding in the fall.

Particularly in the higher altitudes at which wheat is grown, one of the most successful methods is that of seeding directly in stubble without preparation. The stubble should be clean and free from weeds, the ground not too dry, and preferably plowed in the spring before seeding the last crop.

COLORADO.

Winter wheat is one of the best small-grain crops for eastern Colorado. Particularly is this true if it can be sown on carefully prepared land, such as summer tilled, including new breaking of prairie sod, or corn ground. At the Akron Field Station the average yields for the seven years, 1910 to 1916, inclusive, were 23.1 bushels on summer-tilled land and 19.7 bushels on disked corn ground. Following small grains the average yields for the same years were between 13 and 14 bushels per acre, with little difference resulting from variation in time of plowing or other treatment.

KANSAS.

The experimental work of the United States Department of Agriculture in western Kansas has been conducted in cooperation with the State experiment station at the substations at Hays, Garden City, and Colby.

With the decreasing rainfall from east to west in western Kansas, there is a decreasing certainty as to the production of a crop. The northwestern portion of the State shows a better adaptation to winter wheat than the southwestern or Arkansas Valley section. Winter wheat is so much more successful than spring wheat that it is grown almost exclusively. Only in emergency is it replaced with spring wheat, and then with a much lower expectation of a profitable crop.

The early harvest and long season here gives a very marked advantage to earliness in fall plowing or listing. While corn ground has an advantage over late-prepared land, it does not have such an advantage over land prepared immediately after harvest. The latter is in turn exceeded in yield but not in profit per acre by land that is summer tilled. The beneficial effects of summer tillage may be realized in some cases and at the same time a crop of corn may be produced by leaving every other row of corn blank and maintaining clean cultivation. At Hays the average yields per acre for the 9-year period, 1907 to 1916, exclusive of 1912, when the crop was destroyed by hail, were as follows: Summer tilled, 22.7 bushels; listed after winter wheat, 19.2 bushels; early fall plowed after winter wheat, 17.6 bushels; disked corn ground, 15.4 bushels; and late fall plowed after winter wheat, 11 bushels. Where there is great danger from blowing, both blowing and winterkilling are sometimes successfully guarded against by seeding directly in stubble without preparation. Such crops are likely to be more weedy than cultivated land and to suffer more quickly from drought. But as a successful general crop in the western counties, to which this practice is confined, is dependent upon an unusually favorable rainfall during the growing season, this latter objection may not be as vital as might at first appear.

Kafir or other sorghum ground is very poor preparation for wheat in this section. This is contrary to the results farther north, where sorghum ground may be as productive as corn ground.

OKLAHOMA.

Owing to the short period during which the field stations at Woodward and Lawton have been in operation, few experimental data are to be cited from western Oklahoma. Of all the small grains, winter wheat is by far the best adapted to this region. In case of failure it can not be successfully replaced with spring wheat. In this area, the winter pasturage furnished by winter wheat is an important consideration in determining the acreage it occupies. Pasturing is necessary in some seasons to prevent too great a growth.

Summer tillage is not practiced to any great extent, partly perhaps on account of the long season. Where the crop follows small grain, early preparation is essential to the best results. Several months elapse between harvest and seeding. If the ground is plowed or otherwise cultivated during this period, there is a chance for the storage of water which would otherwise be used by weeds.

Unless pasture is a prime consideration, seeding should be late. It is necessary that the plants start growth and become established before winter, but any growth in excess of this uses water during the fall, winter, and early spring that may be needed in drought protection during a later critical period. Corn, bean, and cowpea land is a much better preparation than any of the sorghums, including broom corn.

TEXAS.

Panhandle conditions are represented by the Dalhart and Amarillo Field Stations. The sandy soil on which the Dalhart station is located is not at all adapted to the growth of wheat or any other small grains except winter rye. A good crop of winter wheat may be produced occasionally, but no dependence is to be placed on it.

On the heavier soil represented by the Amarillo substation, the winter-wheat crop is more reliable. An 8-year average of yields at Amarillo varied from 7.1 to 10.6 bushels per acre according to tillage methods. In half the years the yields were fair and in half they were poor. The difference in yields resulting from different methods of preparation was not great in either the good or the poor years. The highest yield, 10.6 bushels, was from summer tillage, but this is less than a bushel more than the yield on early fall plowing of winter-wheat stubble. Small-grain stubble, no matter how treated, was more productive than corn ground.

Late seeding is advisable. This lengthens the period of water storage and reduces the amount of water used by the crop in the fall, winter, and early spring. Farther south, in the region locally known as the South Plains, wheat is more extensively grown than it is in the Panhandle. Presumably this is because it is more successful and more profitable, but no comparative data can be given.

In the territory represented by the Big Spring Field Station, winter wheat is grown to a limited extent. Success with it here is dependent on a season better than the average.

NEW MEXICO.

Winter wheat is the best adapted of any of the small grains except winter rye to eastern New Mexico. It is not adapted to sandy soils, such as that on which the Tucumcari Field Station is located. Its growth is confined to the heavier soils of the level plains and the high altitudes of the mesas. Little advice based on local experimental evidence can be furnished. From all the evidence available it would appear that slightly the highest yields may be obtained from summer-tilled land, but that returns nearly as large, and by far the most profitable, will result from preparation that began as soon as possible after harvest. Winter wheat makes a good first crop on land that is broken long enough before seeding to be filled with water to a depth of 3 feet.

GENERAL CONSIDERATIONS.

From the standpoint of winter wheat production, the Great Plains region divides rather naturally into three sections, merging, of course, rather gradually into each other—the northern, the central, and the southern sections. The northern section includes the Plains portion of Montana and Wyoming, western South Dakota, and a portion of western Nebraska. In this section the average yield of winter wheat is little above that of spring wheat. When it fails to start growth or to survive the winter, its place may be taken by spring wheat without serious loss. The response of the two to cultural methods is generally about the same.

Harvest is late and seeding early. In the northern portion of this area and in the higher altitudes, harvest and seeding time are so near together that old wheat is generally in demand for early seeding. Under these conditions there is no chance to distinguish between early and late plowing or preparation. In the sections where winterkilling is the worst, it is necessary to resort to extreme measures of protection, such as seeding in standing cornstalks or in small-grain stubble without preparation. Corn or other cultivated ground is one of the best preparations in this section.

In the central section, winter wheat is primarily the most important grain crop. It can be replaced with spring wheat only at a decided loss in yield, quality, and certainty of crop. Here there is greater response to cultural conditions. This response being greater for winter wheat than for other grains, that crop should be seeded on the best-prepared land. The season being longer, there is more time between harvest and seeding and consequently a decidedly favorable response to earliness of preparation. Early fall plowing or listing may be exceeded in yield, but generally not in profit per acre by summer tillage. While corn or other cultivated ground is a good preparation in this section, it has not the unqualified superiority over other methods that it has farther north.

In the southern section the expectation of a high average yield is less than in either of the other sections, and at the same time the response to cultural conditions is less. While there may be winterkilling in this section it is not of the great importance it is farther north. In case of winterkilling the crop can not be replaced with spring wheat with any degree of success.

Neither corn ground nor the sorghums, which are grown so extensively here, make a good preparation, although corn ground is much better than sorghum ground. Early preparation is important. Seeding should be late, unless pasture is a prime consideration.

The high price guaranteed for wheat and a laudable patriotic desire to contribute to the world's food supply will undoubtedly lead to the sowing of many fields under conditions from which only failure can reasonably be expected. Effort that results only in the waste of seed is to be discouraged.

In the southern section of the Plains, where the adaptation of wheat is naturally low and where the winter and spring precipitation is normally low, it should be clearly recognized that seeding on dry soil incurs a risk of failure scarcely justified by the chances of success. Precipitation during the winter and spring may be so abnormally heavy as to make a crop, but the chances are very much against it.

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HOUSE RATS AND MICE

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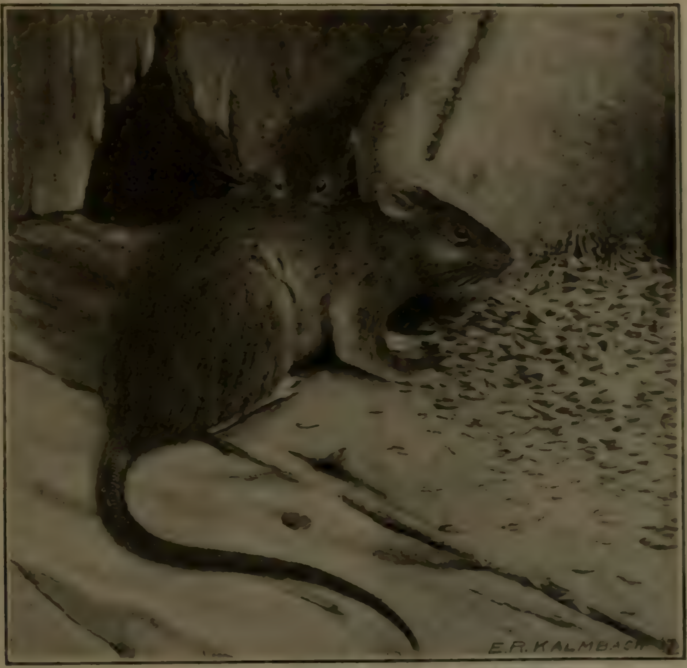

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FARMERS' BULLETIN 896

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Biological Survey
E. W. NELSON, Chief

Washington, D. C. October, 1917

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THE RAT is the worst animal pest in the world.

From its home among filth it visits dwellings and storerooms to pollute and destroy human food.

It carries bubonic plague and many other diseases fatal to man and has been responsible for more untimely deaths among human beings than all the wars of history.

In the United States rats and mice each year destroy crops and other property valued at over $200,000,000.

This destruction is equivalent to the gross earnings of an army of over 200,000 men.

On many a farm, if the grain eaten and wasted by rats and mice could be sold, the proceeds would more than pay all the farmer's taxes.

The common brown rat breeds 6 to 10 times a year and produces an average of 10 young at a litter. Young females breed when only three or four months old.

At this rate a pair of rats, breeding uninterruptedly and without deaths, would at the end of three years (18 generations) be increased to 359,709,482 individuals.

For centuries the world has been fighting rats without organization and at the same time has been feeding them and building for them fortresses for concealment. If we are to fight them on equal terms we must deny them food and hiding places. We must organize and unite to rid communities of these pests. The time to begin is now.

HOUSE RATS AND MICE.

CONTENTS.

Page.
Destructive habits 3
Protection of food and other stores 5
  Rat-proof building 5
  Keeping food from rats and mice 9
Destroying rats and mice 11
  Traps 11
  Poisons 15
  Domestic animals 18
Destroying rats and mice—Continued.
  Fumigation 18
  Rat viruses 19
  Natural enemies 20
Organized efforts to destroy rats 20
  Community efforts 21
  State and national aid 21
Important repressive measures 22

DESTRUCTIVE HABITS OF HOUSE RATS AND MICE.

LOSSES from depredations of house rats amount to many millions of dollars yearly—to more, in fact, than those from all other injurious mammals combined. The common house mouse[1] and the brown rat[2] (fig. 1), too familiar to need description, are pests in nearly all parts of the country; while two other kinds of house rats, known as the black rat[3] and the roof rat,[4] are found within our borders.

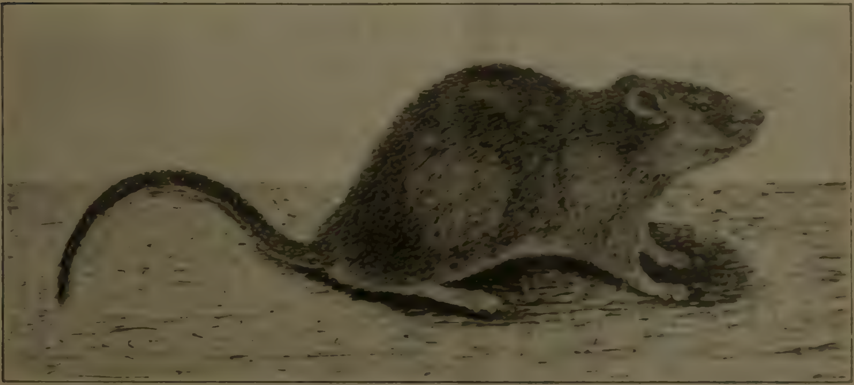

FIG. 1.—Brown rat.

Of these four introduced species—for none is native to America—the brown rat is the most destructive, and, except the mouse, the most numerous and most widely distributed. Brought to America just before the Revolution, it has supplanted and nearly exterminated its less robust relative the black rat; and in spite of the constant warfare of man has extended its range and steadily increased in numbers. Its dominance is due to its great fecundity and its ability to adapt itself to all sorts of surroundings. It breeds (in the middle part of the United States) six or more times a year and produces from 6 to 20 young (average 10) in a litter. Females breed when only 3 or 4 months old. Thus a pair, breeding uninterruptedly and without deaths, could in three years (18 generations) produce a posterity of 359,709,480 individuals. Mice and the black and roof rats produce smaller litters, but the period of gestation, about 21 days, and the number of litters are the same for all.

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[1] *Mus musculus.*

[2] *Rattus norvegicus.*

[3] *Rattus rattus rattus.*

[4] *Rattus rattus alexandrinus.*

Rats and mice are practically omnivorous, feeding upon all kinds of animal and vegetable matter. The brown rat makes its home in the open field, the hedge row, and the river bank, as well as in stone walls, piers, and all kinds of buildings. It destroys grains when newly planted, while growing, and in the shock, stack, mow, crib, granary, mill, elevator, or ship's hold, and also in the bin and feed trough. It invades store and warehouse and destroys furs, laces, silks, carpets, leather goods, and groceries. It attacks fruits, vegetables, and meats in the markets, and destroys by pollution ten times as much as it actually eats. It destroys eggs and young poultry, and eats the eggs and young of song and game birds. It carries disease germs from house to house and bubonic plague from city to city. It causes disastrous conflagrations; floods houses by gnawing lead water pipes; ruins artificial ponds and embankments by burrowing; and damages foundations, floors, doors, and furnishings of dwellings.

Unlike the brown rat the black rat rarely migrates to the fields. It has disappeared from most parts of the Northern States, but is occasionally found in remote villages or farms. At our seaports it frequently arrives on ships from abroad, but seldom becomes very numerous. The roof rat is common in many parts of the South, where it is a persistent pest in cane and rice fields. It maintains itself against the brown rat partly because of its habit of living in trees. The common house mouse by no means confines its activities to the inside of buildings, but is often found in open fields, where its depredations in shock and stack are well known.

Not only are mice and rats, especially the brown rat, a cause of destruction and damage to property, but they are also a constant menace to the health of man. It has been proved that they are the chief means of perpetuating and transmitting bubonic plague and that they play important rôles in conveying other diseases to human beings. They are parasites, without redeeming characteristics, and should everywhere be routed and destroyed.

PROTECTION OF FOOD AND OTHER STORES FROM RATS AND MICE.

Past attempts to exterminate rats and mice have failed, not so much because of lack of effective means as because of the neglect of necessary precautions and the absence of concerted endeavors. We have rendered our work abortive by continuing to provide subsistence and hiding places for the animals. If these advantages are denied, persistent and general use of the usual methods of destruction will prove far more successful.

RAT-PROOF BUILDING.

First in importance, as a measure of rat repression, is the exclusion of the animals from places where they find food and safe retreats for rearing their young.

The best way to keep rats from buildings, whether in city or in country, is to use cement in construction. As the advantages of this material are coming to be generally understood, its use is rapidly extending to all kinds of buildings. The processes of mixing and laying this material require little skill or special knowledge, and workmen of ordinary intelligence can successfully follow the plain directions contained in handbooks of cement construction.[1]

Many modern public buildings are so constructed that rats can find no lodgment in the walls or foundations, and yet in a few years, through negligence, such buildings often become infested with the pests. Sometimes drain pipes are left uncovered for hours at a time. Often outer doors, especially those opening on alleys, are left ajar. A common mistake is failure to screen basement windows which must be opened for ventilation. However the intruders are admitted, when once inside they intrench themselves behind furniture or stores, and are difficult to dislodge. The addition of inner doors to vestibules is an important precaution against rats. The lower edge of outer doors to public buildings, especially markets, should be reinforced with light metal plates to prevent the animals from gnawing through. Any opening left around water, steam, or gas pipes, where they go through walls, should be closed carefully with concrete to the full depth of the wall.

Dwellings.—In constructing dwelling houses the additional cost of making the foundations rat-proof is slight compared with the advantages. The cellar walls should have concrete footings, and the walls themselves should be laid in cement mortar. The cellar floor should be of medium rather than lean concrete. Even old cellars may be made rat-proof at comparatively small expense. Rat holes may be permanently closed with a mixture of cement, sand, and broken glass, or sharp bits of crockery or stone.

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[1] Farmers' Bulletin 461, Use of Concrete on the Farm, will prove useful to city and village dwellers as well as to the farmer.

On a foundation like the one described above, the walls of a wooden dwelling also may be made rat-proof. The space between the sheathing and lath, to the height of about a foot, should be filled with concrete. Rats can not then gain access to the walls, and can enter the dwelling only through doors or windows. Screening all basement and cellar windows with wire netting is a most necessary precaution.

Old buildings in cities.—Aside from old dwellings, the chief refuges for rats in cities are sewers, wharves, stables, and outbuildings. Modern sewers are used by the animals merely as highdays and not as abodes, but old-fashioned brick sewers often afford nesting crannies.

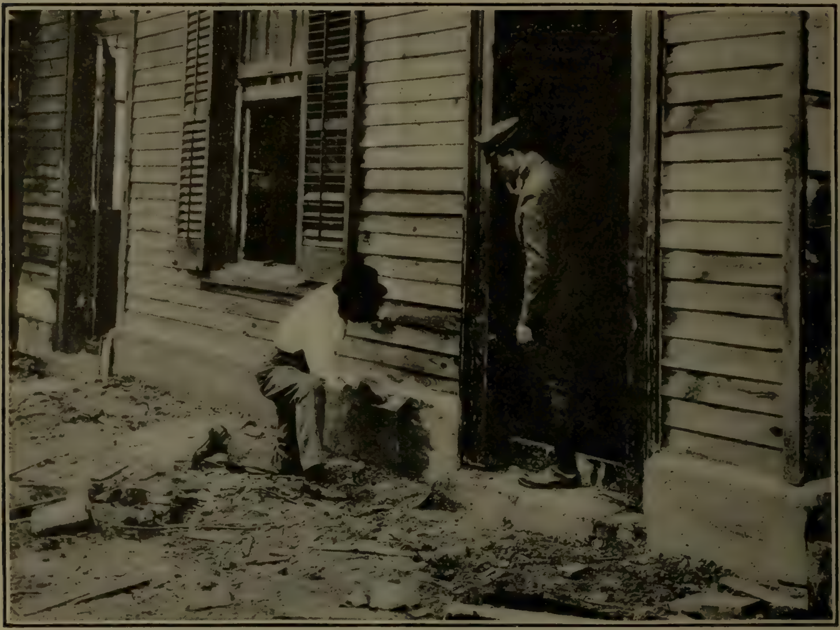
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FIG. 2.—Rat-proofing a frame dwelling by concrete side wall (United States Public Health Service, New Orleans, La., 1914).

Wharves, stables, and outbuildings in cities should be so built as to exclude rats. Cement is the chief means to this end. Old tumble-down buildings and wharves should not be tolerated in any city. (See fig. 2.)

In both city and country, wooden floors of sidewalks, areas, and porches are commonly laid upon timbers resting on the ground. Under such floors rats have a safe retreat from nearly all enemies. The conditions can be remedied in towns by municipal action requiring that these floors be replaced by others made of cement. Areas or walks made of brick are often undermined by rats and may become as objectionable as those of wood. Wooden floors of porches should always be well above the ground.

Farm buildings.—Granaries, corncribs, and poultry houses may be made rat-proof by a liberal use of cement in the foundations and floors; or the floors may be of wood resting upon concrete. Objection has been urged against concrete floors for horses, cattle, and poultry, because the material is too good a conductor of heat, and the health of the animals suffers from contact with these floors. In poultry houses, dry soil or sand may be used as a covering for the cement floor, and in stables a wooden floor resting on concrete is just as satisfactory so far as the exclusion of rats is concerned.

The common practice of setting corncribs on posts with inverted pans at the top often fails to exclude rats, because the posts are not high enough to place the lower cracks of the structure beyond reach of the animals. As rats are excellent jumpers, the posts should be tall enough to prevent the animals from obtaining a foothold at any place within 3 feet of the ground. A crib built in this way, however, is not very satisfactory.

For a rat-proof crib a well-drained site should be chosen. The outer walls, laid in cement, should be sunk about 20 inches into the ground. The space within the walls should be grouted thoroughly with cement and broken stone and finished with rich concrete for a floor. Upon this the structure may be built. Even the walls of the crib may be of concrete. Corn will not mold in contact with them, provided there is good ventilation and the roof is water-tight.

However, there are cheaper ways of excluding rats from either new or old corncribs. Rats, mice, and sparrows may be kept out effectually by the use of either an inner or an outer covering of galvanized-wire netting of half-inch mesh and heavy enough to resist the teeth of the rats. The netting in common use in screening cellar windows is suitable for covering or lining cribs. As rats can climb the netting, the entire structure must be screened, or, if sparrows are not to be excluded, the wire netting may be carried up about 3 feet from the ground, and above this a belt of sheet metal about a foot in width may be tacked to the outside of the building.

Complete working drawings for the practical rat-proof corncrib shown in figures 3 and 4 may be obtained from the Office of Public Roads and Rural Engineering of the department.

Buildings for storing foodstuffs.—Whenever possible, stores of food for man or beast should be placed only in buildings of rat-proof construction, guarded against rodents by having all windows near the ground and all other possible means of entrance screened with netting made of No. 18 or No. 20 wire and of ¼-inch mesh. Entrance doors should fit closely, should have the lower edges protected by wide strips of metal, and should have springs attached, to insure that they shall not be left open. Before being used for housing stores, the building should be inspected as to the manner in which water,

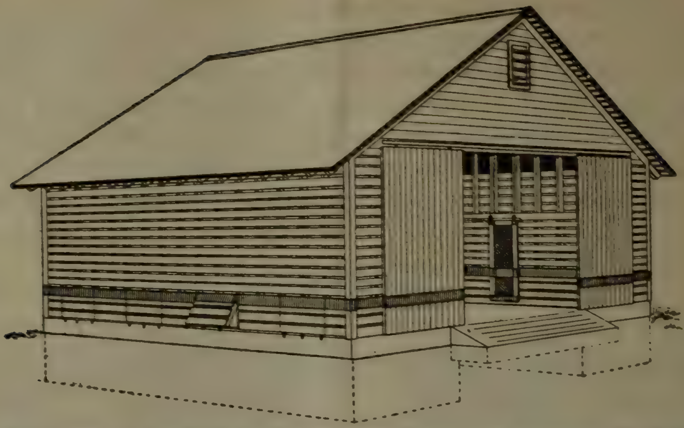

FIG. 3.—Perspective of rat-proof corncrib, showing concrete foundation by dotted lines; also belt of metal.

steam, or gas pipes go through the walls, and any openings found around such pipes should be closed with concrete.

If rat-proof buildings are not available, it is possible, by the use of concrete in basements and the other precautions just mentioned, to make an ordinary building practically safe for food storage.

When it is necessary to erect temporary wooden structures to hold forage, grain, or food supplies for army camps, the floors of such buildings should not be in contact with the ground, but elevated, the sills having a foot or more of clear space below them. Smooth posts rising 2 or 3 feet above the ground may be used for foundations, and the floor itself may be protected below by wire netting or sheet metal at all places where rats could gain a foothold. Care should be taken to have the floors as tight as possible, for it is chiefly scattered grain and fragments of food about a camp that attract rats.

Rat-proofing by elevation.—The United States Public Health Service reports that in its campaigns against bubonic plague in San Francisco (1907) and New Orleans (1914) many plague rats were found under the floors of wooden houses resting on the ground. These buildings were made rat-proof by elevation, and no case of either human or rodent plague occurred in any house after the change. Placing them on smooth posts 18 inches above the ground, with the space beneath the floor entirely open, left no hiding place for rats.

This plan is adapted to small dwellings throughout the South, and to small summer homes, temporary structures, and small farm buildings everywhere. Wherever rats might obtain a foothold on the top of the post they may be prevented from gnawing the adjacent wood by tacking metal plates or pieces of wire netting to floor or sill.

KEEPING FOOD FROM RATS AND MICE.

The effect of an abundance of food on the breeding of rodents should be kept in mind. Well-fed rats mature quickly, breed often, and have large litters. Poorly fed rats, on the contrary, reproduce less frequently and have smaller litters. In addition, scarcity of food makes measures for destroying the animals far more effective.

Merchandise in stores.—In all parts of the country there is a serious economic drain in the destruction by rats and mice of merchandise held for sale by dealers. Not only foodstuffs and forage, but textiles, clothing, and leather goods are often ruined. This loss is due mainly to the faulty buildings in which the stores are kept. Often it would be a measure of economy to tear down the old structures and replace them by new ones. However, even the old buildings may often be repaired so as to make them practically rat-proof; and foodstuffs, as flour, seeds, and meats, may always be protected in wire cages at slight expense. The public should be protected from insanitary stores by a system of rigid inspection.

Household supplies.—Similar care should be exercised in the home to protect household supplies from mice and rats. Little progress in ridding the premises of these animals can be made so long as they have access to supplies of food. Cellars, kitchens, and pantries often furnish subsistence not only to rats that inhabit the dwelling, but to many that come from outside. Food supplies may always be kept from rats and mice if placed in inexpensive rat-proof containers covered with wire netting. Sometimes all that is needed to prevent

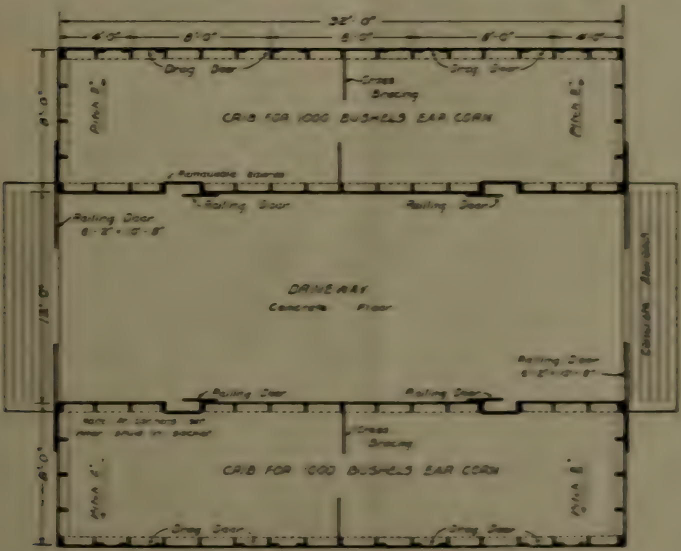

FIG. 4.—Floor plan of rat-proof corncrib shown in figure 3.

serious waste is the application of concrete to holes in the basement wall or the slight repair of a defective part of the building.

Produce in transit.—Much loss of fruits, vegetables, and other produce occurs in transit by rail and on ships. Most of the damage is done at wharves and in railway stations, but there is also considerable in ships' holds, especially to perishable produce brought from warm latitudes. Much of this may be prevented by the use of rat-proof cages at the docks, by the careful fumigation of seagoing vessels at the end of each voyage, and by the frequent fumigation of vessels in coastwise trade; but still more by replacing old and decrepit wharves and station platforms with modern ones built of concrete.

Where cargoes are being loaded or unloaded at wharves or depots, food liable to attack by rats may be temporarily safeguarded by being placed in rat-proof cages, or pounds, constructed of wire netting. Wooden boxes containing reserve food held in depots for a considerable time or intended for shipment by sea may be made rat-proof by light coverings of metal along the angles. This plan has long been in use to protect naval stores on ships and in warehouses. It is based on the fact that rats do not gnaw the plane surfaces of hard materials, but attack doors, furniture, and boxes at the angles only.

Packing houses.—Packing houses and abattoirs are often sources from which rats secure subsistence, especially where meats are prepared for market in old buildings. In old-style cooling rooms with double walls of wood and sawdust insulation, always a source of annoyance because of rat infestation, the utmost vigilance is required to prevent serious loss of meat products. On the other hand, packing houses with modern construction and sanitary devices have no trouble from rats or mice.

Garbage and waste.—Since much of the food of rats consists of garbage and other waste materials, it is not enough to bar the animals from markets, granaries, warehouses, and private food stores. Garbage and offal of all kinds must be so disposed of that rats can not obtain them.

In cities and towns an efficient system of garbage collection and disposal should be established by ordinances. Waste from markets, hotels, cafés, and households should be collected in covered metal receptacles and frequently emptied. Garbage should never be dumped in or near towns, but should be utilized or promptly destroyed by fire.

Rats find abundant food in country slaughterhouses; reform in the management of these is badly needed. Such places are centers of rat propagation. It is a common practice to leave offal of slaughtered animals to be eaten by rats and swine, and this is the chief means of perpetuating trichinæ in pork. The law should require that offal be promptly cremated or otherwise disposed of. Country slaughterhouses should be as cleanly and as constantly inspected as abbatoirs.

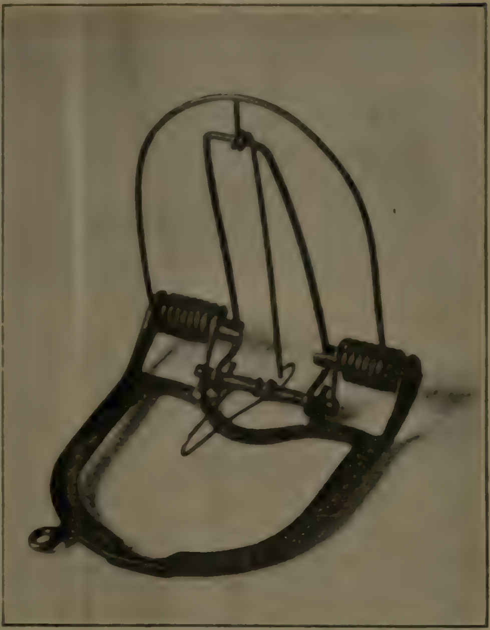

FIG. 5.—Guillotine trap made entirely of metal.

Another important source of rat food is found in remnants of lunches left by employees in factories, stores, and public buildings. This food, which alone is sufficient to attract and sustain a small army of rats, is commonly left in waste baskets or other open receptacles. Strictly enforced rules requiring all remnants of food to be deposited in covered metal vessels would make trapping far more effective.

Military training camps, unless subjected to rigid discipline in the matter of disposal of garbage and waste, soon become centers of rat infestation. Waste from camps, deposited in covered metal cans and collected daily, should be removed far from the camp itself and either burned or utilized in approved modern ways.

DESTROYING RATS AND MICE.

The Biological Survey has made numerous laboratory and field experiments with various agencies for destroying rats and mice. The results form the chief basis for the following recommendations:

TRAPS.

Owing to their cunning, it is not always easy to clear rats from premises by trapping; if food is abundant, it is impossible. A few adults refuse to enter the most innocent-looking trap. And yet trapping, if persistently followed, is one of the most effective ways of destroying the animals.

Guillotine trap.—For general use the improved modern traps with a wire fall released by a baited trigger and driven by a coiled spring have marked advantages over the old forms, and many of them may be used at the same time. These traps, sometimes called "guillotine" traps, are of many designs, but the more simply constructed are preferable. Probably those made entirely of metal are the best, as they are more durable. Traps with tin or sheet-metal bases are not recommended.

Guillotine traps of the type shown in figure 5 should be baited with small pieces of Vienna sausage (Wienerwurst) or fried bacon. A small section of an ear of corn is an excellent bait if other grain is not present. The trigger wire should be bent inward to bring the bait into proper position for the fall to strike the rat in the neck, as shown in figure 6.

Other excellent baits for rats and mice are oatmeal, toasted cheese, toasted bread (buttered), fish, fish offal, fresh liver, raw meat, pine nuts, apples, carrots, and corn, and sunflower, squash, or pumpkin seeds. Broken fresh eggs are good bait at all seasons, and ripe tomatoes, green cucumbers, and other fresh vegetables are very tempting to the animals in winter. When seed, grain, or meal is used with a guillotine trap, it is put on the trigger plate, or the trigger wire may be bent outward and the bait placed directly under it.

Oatmeal (rolled oats) is recommended as a bait for guillotine traps made with wooden base and trigger plate (fig. 7). These traps are especially convenient to use on ledges or other narrow rat runs or at the openings of rat burrows. They are often used without bait.

A common mistake in trapping for rats and mice is to use only one or two traps when dozens are needed. For a large establishment hundreds of traps may be used to advantage, and a dozen is none too many for an ordinary barn or dwelling infested with rats. House mice are less suspicious than rats and are much more easily trapped.

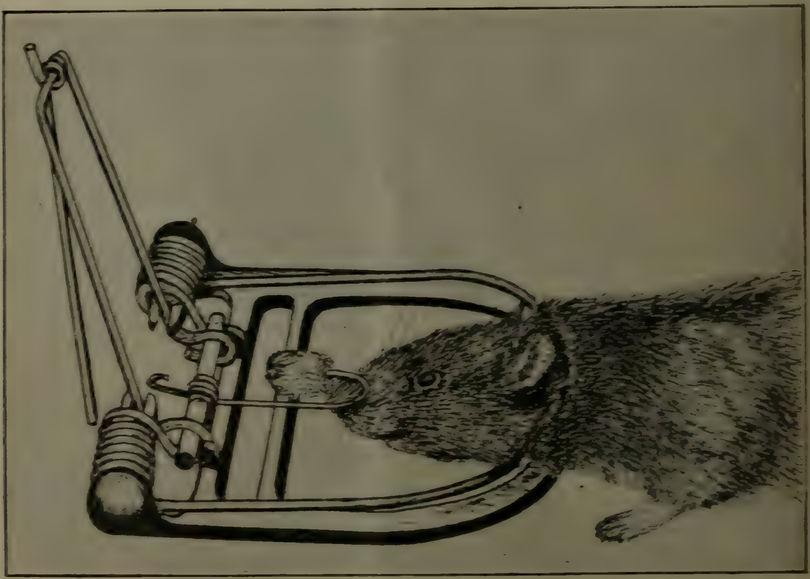

FIG. 6.—Method of baiting guillotine trap.

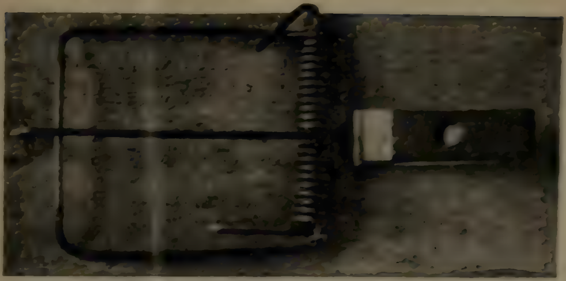

FIG. 7.—Guillotine trap with wooden base and trigger plate.

Small guillotine traps baited with oatmeal will soon rid an ordinary dwelling of the smaller pests.

Cage trap.—When rats are abundant, the large French wire cage traps may be used to advantage. They should be made of stiff wire, well reinforced. Many of those sold in stores are useless, because a full-grown rat can bend the light wires apart and so escape.

Cage traps may be baited and left open for several nights until the rats are accustomed to enter them to obtain food. They should then be closed and freshly baited, when a larger catch may be expected, especially of young rats (fig. 8). As many as 25, and even more, partly grown rats have been taken at a time in one of these traps. It is better to cover the trap than to leave it exposed. A short board should be laid on the trap and an old cloth or bag or a bunch of hay or straw thrown carelessly over the top. Often the trap may be placed with the entrance opposite a rat hole and fitting it so closely that rats can not pass through without entering the trap. If a single rat is caught it may be left in the trap as a decoy to others.

Notwithstanding the fact that sometimes a large number of rats may be taken at a time in cage traps, a few good guillotine traps intelligently used will prove more effective in the long run.

Figure-4 trigger trap.—The old-fashioned box trap set with a figure-4 trigger is sometimes useful to secure a wise old rat that refuses to be enticed into a modern trap. Better still is a simple deadfall—

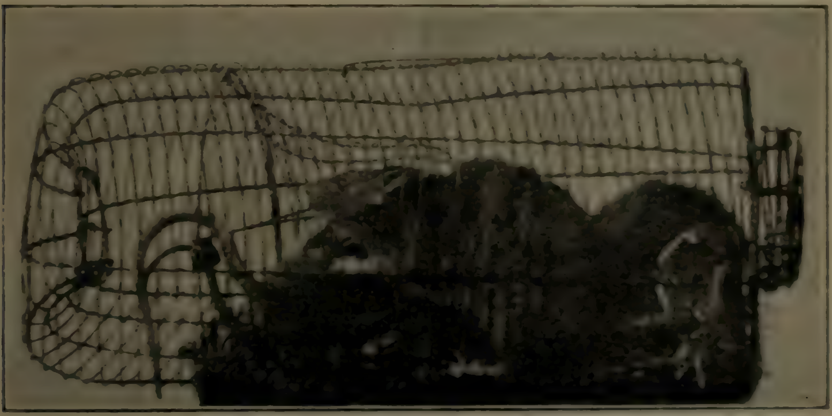

FIG. 8.—Cage trap with catch of rats.

a flat stone or a heavy plank—supported by a figure-4 trigger. An old rat will go under such a contrivance to feed without fear.

Steel trap.—The ordinary steel trap (No. 0 or 1) may sometimes be satisfactorily employed to capture a rat. The animal is usually caught by the foot, and its squealing has a tendency to frighten other rats. The trap may be set in a shallow pan or box and covered with bran or oats, care being taken to have the space under the trigger pan free of grain. This may be done by placing a very little cotton under the trigger and setting as lightly as possible. In a narrow run or at the mouth of a burrow a steel trap unbaited and covered with very light cloth or tissue paper is often effective.

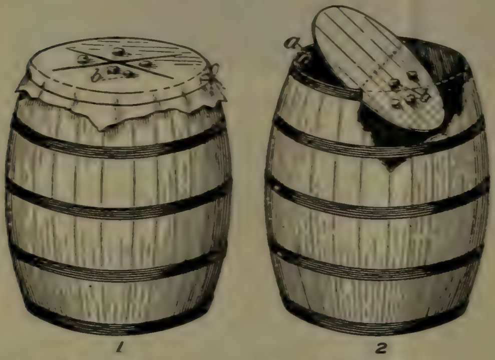

FIG. 9.—Barrel trap: 1, With stiff paper cover; 2, with hinged barrel cover; *a*, stop; *b*, baits.

The best bait usually is food of a kind that the rats and mice do not get in the vicinity. In a meat market, vegetables or grain should be used; in a feed store, meat. As far as possible food other than the bait should be inaccessible while trapping is in progress. The bait should be kept fresh and attractive, and the kind changed when necessary. Baits and traps should be handled as little as possible.

Barrel trap.—About 60 years ago a writer in the Cornhill Magazine gave details of a trap, by means of which it was claimed that 3,000 rats were caught in a warehouse in a single night. The plan involved tolling the rats to the place and feeding them for several nights on the tops of barrels covered with coarse brown paper. Afterwards a cross was cut in the paper, so that the rats fell into the barrel (fig. 9 (1)). Many variations of the plan, but few improvements upon it, have been suggested by agricultural writers since that time. Reports are frequently made of large catches of rats by means of a barrel fitted with a light cover of wood, hinged on a rod so as to turn with the weight of a rat (fig. 9 (2)).

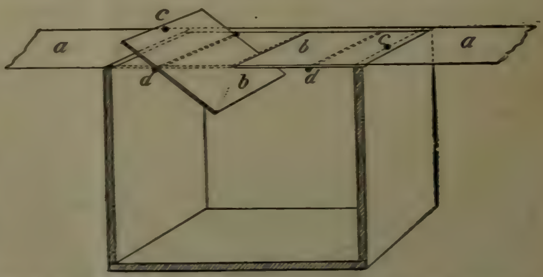

FIG. 10.—Pit trap. *aa*, Rat run; *bb*, cover; *cc*, position of weights; *dd*, rods on which covers turn.

Pit trap.—A modification of the barrel trap is the pit trap (fig. 10). This consists of a stout narrow box sunk in the ground so that the top is level with the rat run. It is fixed with a cover of light wood or metal in two sections, the sections fitting nicely inside the box and working independently. They turn on rods, to which they are fastened. They are weighted near the ends of the box and so adjusted that they swing easily. An animal stepping upon the cover beyond the rods is precipitated into the box, while the cover immediately swings back to its place. Besides rats, the trap is well adapted to capture larger animals, as minks, raccoons, opossums, and cats. It is especially useful to protect poultry yards, game preserves, and the like. The trap should be placed along the fence outside the yard, and behind a shelter of boards or brush that leans against the fence.

Fence and battue.—In the rice fields of the Far East the natives build numerous piles of brush and rice straw, and leave them for several days until many rats have taken shelter in them. A portable bamboo inclosure several feet in height is then set up around each pile in succession and the straw and brush are thrown out over the top, while dogs and men kill the trapped rodents. Large numbers are destroyed in this way, and the plan with modifications may be utilized in America with satisfactory results. A wire netting of fine mesh may be used for the inclosure. The scheme is applicable at the removal of grain, straw, or haystacks, as well as brush piles.

In a large barn near Washington, a few years ago, piles of unhusked corn were left in the loft and were soon infested with rats. A wooden pen was set down surrounding the piles in turn and the corn thrown out until dogs were able to get at the rats. In this way several men and dogs killed 500 rats in a single day.

POISONS.

While the use of poison is the best and quickest way to get rid of rats and mice, the odor from the dead animals makes the method impracticable in occupied houses. Poisons may be effectively used in barns, stables, sheds, cribs, and other outbuildings.

Caution.—In the United States there are few laws which prohibit the laying of poisons on lands owned or controlled by the poisoner. Hence it is all the more necessary to exercise extreme caution to prevent accidents. In several States notice of intention to lay poison must be given to persons living in the neighborhood. Poison for rats should never be placed in open or unsheltered places. This applies particularly to strychnin or arsenic on meat. *Packages containing poisons should always bear a warning label and should not be kept where children might reach them.*

Among the principal poisons that have been recommended for killing rats and mice are barium carbonate, strychnin, arsenic, phosphorus, and squills.

Barium carbonate.—One of the cheapest and most effective poisons for rats and mice is barium carbonate. This mineral has the advantage of being without taste or smell. It has a corrosive action on the mucous lining of the stomach and is dangerous to larger animals if taken in sufficient quantity. In the small doses fed to rats and mice it would be harmless to domestic animals. Its action upon rats is slow, and if exit is possible the animals usually leave the premises in search of water. For this reason the poison may frequently, though not always, be used in houses without disagreeable consequences.

Barium carbonate may be fed in the form of dough composed of four parts of meal or flour and one part of the mineral. A more convenient bait is ordinary oatmeal with about one-eighth of its bulk of the mineral, mixed with water into a stiff dough. A third plan is to spread the barium carbonate upon fish, toasted bread (moistened), or ordinary bread and butter. The prepared bait should be placed in rat runs, about a teaspoonful at a place. If a single application of the poison fails to kill or drive away all rats from the premises, it should be repeated with a change of bait.

Strychnin.—Strychnin is too rapid in action to make its use for rats desirable in houses, but elsewhere it may be employed effectively. Strychnia sulphate is the best form to use. The dry crystals may be inserted in small pieces of raw meat, Vienna sausage, or toasted cheese, and these placed in rat runs or burrows; or oatmeal may be moistened with a strychnin sirup and small quantities laid in the same way.

Strychnin sirup is prepared as follows: Dissolve a half ounce of strychnia sulphate in a pint of boiling water; add a pint of thick sugar sirup and stir thoroughly. A smaller quantity may be prepared with a proportional quantity of water and sirup. In preparing the bait it is necessary to moisten all the oatmeal with the sirup. Wheat and corn are excellent alternative baits. The grain should be soaked overnight in the strychnin sirup.

Arsenic.—Arsenic is probably the most popular of the rat poisons, owing to its cheapness, yet our experiments prove that, measured by the results obtained, arsenic is dearer than strychnin. Besides, arsenic is extremely variable in its effect upon rats, and if the animals survive a first dose it is very difficult to induce them to take another.

Powdered white arsenic (arsenious acid) may be fed to rats in almost any of the baits mentioned under barium carbonate and strychnin. It has been used successfully when rubbed into fresh fish or spread on buttered toast. Another method is to mix twelve parts by weight of corn meal and one part of arsenic with whites of eggs into a stiff dough.

An old formula for poisoning rats and mice with arsenic is the following, adapted from an English source:

Take a pound of oatmeal, a pound of coarse brown sugar, and a spoonful of arsenic. Mix well together and put the composition into an earthen jar. Put a tablespoonful at a place in runs frequented by rats.

Phosphorus.—For poisoning rats and mice, phosphorus is used almost as commonly as arsenic, and undoubtedly it is effective when given in an attractive bait. The phosphorus paste of the drug stores is usually dissolved yellow phosphorus, mixed with glucose or other substances. The proportion of phosphorus varies from one-fourth of 1 per cent to 4 per cent. The first amount is too small to be always effective and the last is dangerously inflammable. When homemade preparations of phosphorus are used there is much danger of burning the person or of setting fire to crops or buildings. In the Western States many fires have resulted from putting out homemade phosphorus poisons for ground squirrels, and entire fields of ripe grain have been destroyed in this way. Even with commercial pastes the action of sun and rain changes the phosphorus and leaches out the glucose until a highly inflammable residue is left.

It is often claimed that phosphorus eaten by rats or mice dries up or mummifies the body so that no odor results. The statement has no foundation in fact. No known poison will prevent decomposition of the body of an animal that died from its effects. Equally misleading is the statement that rats poisoned with phosphorus do not die on the premises. Owing to its slower operation, no doubt a larger portion escape into the open before dying than when strychnin is used.

The Biological Survey does not recommend the use of phosphorus as a poison for rodents.

Squills.—The squill, or sea leek,[1] is a favorite rat poison in many parts of Europe and is well worthy of trial in America. It is rapid and very deadly in its action, and rats seem to eat it readily. The poison is used in several ways. Two ounces of dry squills, powdered, may be thoroughly mixed with eight ounces of toasted cheese or of butter and meal and put out in runs of rats or mice. Another formula recommends two parts of squills to three parts of finely chopped bacon, mixed with meal enough to make it cohere. This is baked in small cakes.

Poison in poultry houses.—For poisoning rats in buildings and yards occupied by poultry the following method is recommended: Two wooden boxes should be used, one considerably larger than the other and each having one or more holes in the sides large enough to admit rats. The poisoned bait should be placed on the bottom and near the middle of the smaller box, and the larger box should then be inverted over it. Rats thus have free access to the bait, but fowls are excluded.

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[1] *Scilla maritima.*

DOMESTIC ANIMALS.

Among domestic animals employed to kill rats are the dog, the cat, and the ferret.

Dogs.—The value of dogs as ratters can not be appreciated by persons who have had no experience with a trained animal. The ordinary cur and the larger breeds of dogs seldom develop the necessary qualities for ratters. Small Irish, Scotch, and fox terriers, when properly trained, are superior to other breeds and under favorable circumstances may be relied upon to keep the farm premises reasonably free from rats.

Cats.—However valuable cats may be as mousers, few learn to catch rats. The ordinary house cat is too well fed and consequently too lazy to undertake the capture of an animal as formidable as the brown rat. Birds and mice are much more to its liking. Cats that are fearless of rats, however, and have learned to hunt and destroy them are often very useful about stables and warehouses. They should be lightly fed, chiefly on milk. A little sulphur in the milk at intervals is a corrective against the bad effects of a constant rat or mouse diet. Cats often die from eating these rodents.

Ferrets.—Tame ferrets, like weasels, are inveterate foes of rats, and can follow the rodents into their retreats. Under favorable circumstances they are useful aids to the rat catcher, but their value is greatly overestimated. For effective work they require experienced handling and the additional services of a dog or two. Dogs and ferrets must be thoroughly accustomed to each other, and the former must be quiet and steady instead of noisy and excitable. The ferret is used only to bolt the rats, which are killed by the dogs. If unmuzzled ferrets are sent into rat retreats, they are apt to make a kill and then lie up after sucking the blood of their victim. Sometimes they remain for hours in the burrows or escape by other exits and are lost. There is danger that these lost ferrets may adapt themselves to wild conditions and become a pest by preying upon poultry and birds.

FUMIGATION.

Rats may be destroyed in their burrows in the fields and along river banks, levees, and dikes by carbon bisulphid.[1] A wad of cotton or other absorbent material is saturated with the liquid and then pushed into the burrow, the opening being packed with earth to prevent the escape of the gas. All animals in the burrow are asphyxiated. Fumigation in buildings is not so satisfactory, because it is difficult to confine the gases. Moreover, when effective, the odor from the dead rats is highly objectionable in occupied buildings.

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[1] CAUTION.—Carbon disulphid is very inflammable and can be ignited by a match, lantern, cigar, or pipe.

Chlorin, carbon monoxid, sulphur dioxid, and hydrocyanic acid are the gases most used for destroying rats and mice in sheds, warehouses, and stores. Each is effective if the gas can be confined and made to reach the retreats of the animals. Owing to the great danger from fire incident to burning charcoal or sulphur in open pans, a special furnace provided with means for forcing the gas into the compartments of vessels or buildings is generally employed.

Hydrocyanic-acid gas is effective in destroying all animal life in buildings. It has been successfully used to free elevators and warehouses of rats, mice, and insects. However, it is so dangerous to human life that the novice should not attempt fumigation with it, except under careful instructions. Directions for preparing and using the gas may be found in a publication entitled Hydrocyanic-acid Gas against Household Insects, by Dr. L. O. Howard and Charles H. Popenoe.[1]

Carbon monoxid is rather dangerous, as its presence in the hold of a vessel or other compartment is not manifest to the senses, and fatal accidents have occurred during its employment to fumigate vessels.

Chlorin gas has a strong bleaching action upon textile fabrics, and for this reason can not be used in many situations.

Sulphur dioxid also has a bleaching effect upon textiles, but less marked than that of chlorin, and ordinarily it is not noticeable with the small percentage of the gas it is necessary to use. On the whole, this gas has many advantages as a fumigator and disinfectant. It is used also as a fire extinguisher on board vessels. Special furnaces for generating the gas and forcing it into the compartments of ships and buildings are on the market, and many steamships and docks are now fitted with the necessary apparatus.

RAT VIRUSES.

Several microorganisms, or bacteria, found originally in diseased rats or mice, have been exploited for destroying rats. A number of these so-called rat viruses are on the American market. The Biological Survey, the Bureau of Animal Industry, and the United States Public Health Service have made careful investigations and practical tests of these viruses, mostly with negative results. The cultures tested by the Biological Survey have not proved satisfactory.

The chief defects to be overcome before the cultures can be recommended for general use are:

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[1] Farmers' Bulletin 699.

1. The virulence is not great enough to kill a sufficiently high percentage of rats that eat food containing the microorganisms.

2. The virulence decreases with the age of the cultures. They deteriorate in warm weather and in bright sunlight.

3. The diseases resulting from the microorganisms are not contagious and do not spread by contact of diseased with healthy animals.

4. The comparative cost of the cultures is too great for general use. Since they have no advantages over the common poisons, except that they are usually harmless to man and other animals, they should be equally cheap; but their actual cost is much greater. Moreover, considering the skill and care necessary in their preparation, it is doubtful if the cost can be greatly reduced.

The Department of Agriculture, therefore, does not prepare, use, or recommend the use of rat viruses.

NATURAL ENEMIES OF RATS AND MICE.

Among the natural enemies of rats and mice are the larger hawks and owls, skunks, foxes, coyotes, weasels, minks, dogs, cats, and ferrets.

Probably the greatest factor in the increase of rats, mice, and other destructive rodents in the United States has been the persistent killing off of the birds and mammals that prey upon them. Animals that on the whole are decidedly beneficial, since they subsist upon harmful insects and rodents, are habitually destroyed by some farmers and sportsmen because they occasionally kill a chicken or a game bird.

The value of carnivorous mammals and the larger birds of prey in destroying rats and mice should be more fully recognized, especially by the farmer and the game preserver. Rats actually destroy more poultry and game, both eggs and young chicks, than all the birds and wild mammals combined; yet some of their enemies among our most useful birds of prey and carnivorous mammals are persecuted almost to the point of extinction. An enlightened public sentiment should cause the repeal of all bounties on these animals and afford protection to the majority of them.

ORGANIZED EFFORTS TO DESTROY RATS.

The necessity of cooperation and organization in the work of rat destruction is of the utmost importance. To destroy all the animals on the premises of a single farmer in a community has little permanent value, since they are soon replaced from near-by farms. If, however, the farmers of an entire township or county unite in efforts to get rid of rats, much more lasting results may be attained. If continued from year to year, such organized efforts are very effective.

COMMUNITY EFFORTS.

Cooperative efforts to destroy rats have taken various forms in different localities. In cities, municipal employees have occasionally been set at work hunting rats from their retreats, with at least temporary benefit to the community. Thus, in 1904, at Folkestone, England, a town of about 25,000 inhabitants, the corporation employees, helped by dogs, in three days killed 1,645 rats.

Side hunts in which rats are the only animals that count in the contest have sometimes been organized and successfully carried out. At New Burlington, Ohio, a rat hunt took place some years ago in which each of the two sides killed over 8,000 rats, the beaten party serving a banquet to the winners.

There is danger that organized rat hunts will be followed by long intervals of indifference and inaction. This may be prevented by offering prizes covering a definite period of effort. Such prizes accomplish more than municipal bounties, because they secure a friendly rivalry which stimulates the contestants to do their utmost to win.

In England and some of its colonies contests for prizes have been organized to promote the destruction of the English, or house, sparrow, but many of the so-called sparrow clubs are really sparrow and rat clubs, for the destruction of both pests is the avowed object of the organizations. A sparrow club in Kent, England, accomplished the destruction of 28,000 sparrows and 16,000 rats in three seasons by the annual expenditure of but £6 ($29.20) in prize money. Had ordinary bounties been paid for this destruction, the tax on the community would have been about £250 (over $1,200).

Many organizations already formed should be interested in destroying rats. Boards of trade, civic societies, and citizens' associations in towns and farmers' and women's clubs in rural communities will find the subject of great importance. Women's municipal leagues in several large cities already have taken up the matter. The league in Baltimore recently secured appropriations of funds for expenditure in fighting mosquitoes, flies, and rats. The league in Boston during the past year, supported by voluntary contributions for the purpose, made a highly creditable educational campaign against rats. Boys' corn clubs, the troops of Boy Scouts, and similar organizations could do excellent work in rat campaigns.

STATE AND NATIONAL AID.

To secure permanent results any general campaign for the elimination of rats must aim at *building the animals out of shelter and food.* Building reforms depend on municipal ordinances and legislative enactments. The recent plague eradication work of the United States Public Health Service in San Francisco, Seattle, New Orleans, and at various places in Hawaii and Porto Rico required such ordinances and laws as well as financial aid in prosecuting the work. The campaign of Danish and Swedish organizations for the destruction of rats had the help of governmental appropriations. The legislatures of California, Texas, Indiana, and Hawaii have in recent years passed laws or made appropriations to aid in rat riddance. It is probable that well-organized efforts of communities would soon win legislative support everywhere. Communities should not postpone efforts, however, while waiting for legislative cooperation, but should at once organize and begin repressive operations. Wherever health is threatened the Public Health Service of the United States can cooperate, and where crops and other products are endangered the Bureau of Biological Survey of the Department of Agriculture is ready to assist by advice and in demonstration of methods.

IMPORTANT REPRESSIVE MEASURES.

The measures needed for repressing and eliminating rats and mice include the following:

1. The requirement that all new buildings erected shall be made rat-proof under competent inspection.
2. That all existing rat-proof buildings shall be closed against rats and mice by having all openings accessible to the animals, from foundation to roof, closed or screened by door, window, grating, or meshed wire netting.
3. That all buildings not of rat-proof construction shall be made so by remodeling, by the use of materials that may not be pierced by rats, or by elevation.
4. The protection of our native hawks, owls, and smaller predatory mammals—the natural enemies of rats.
5. Greater cleanliness about markets, grocery stores, warehouses, courts, alleys, stables, and vacant lots in cities and villages, and like care on farms and suburban premises. This includes the storage of waste and garbage in tightly covered vessels and the prompt disposal of it each day.
6. Care in the construction of drains and sewers, so as not to provide entrance and retreat for rats. Old brick sewers in cities should be replaced by concrete or tile.
7. The early threshing and marketing of grains on farms, so that stacks and mows shall not furnish harborage and food for rats.
8. Removal of outlying straw stacks and piles of trash or lumber that harbor rats in fields and vacant lots.

9. The keeping of provisions, seed grain, and foodstuffs in rat-proof containers.

10. Keeping effective rat dogs, especially on farms and in city warehouses.

11. The systematic destruction of rats, whenever and wherever possible, by (*a*) trapping, (*b*) poisoning, and (*c*) organized hunts.

12. The organization of clubs and other societies for systematic warfare against rats.

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Cottontail Rabbits in Relation to Trees and Farm Crops. (Farmers' Bulletin 702.)
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FLEAS
and Their Control

F. C. BISHOPP

ENTOMOLOGIST, INSECTS AFFECTING THE HEALTH OF ANIMALS

Adult Female of the Human Flea, Greatly Enlarged

FARMERS' BULLETIN 897

UNITED STATES DEPARTMENT OF AGRICULTURE

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OF THE APPROXIMATELY 500 species of fleas known to exist, less than one dozen are of special interest as pests to man and domestic animals, but any individual of one of these few species, when bent upon satisfying its appetite, fully occupies the attention of its chosen host.

The human flea, dog flea, cat flea, sticktight flea or chicken flea, and the rat fleas (which carry the bubonic plague), are the principal species that annoy man and domestic animals in the United States.

The main steps in control, as described in this bulletin, are the elimination of breeding places and the destruction of fleas on the infested animals. If breeding places receive proper attention the premises often will be cleared of fleas, even though little or no attention is given to the animals themselves.

Fleas breed in greatest numbers in accumulations of vegetable and animal matter protected from wind and rain, but at the same time furnished with shade and a certain amount of moisture. All live stock should be prevented from going beneath buildings, the vegetable and animal matter carefully cleaned up, and the ground where the immature fleas are developing covered with salt and thoroughly wet down. House infestations may be prevented by eliminating pet animals and applying gasoline to the floors after all rugs have been removed and the floors thoroughly scrubbed with soap and water. Washing pet animals in a comparatively weak solution of saponified creosote or kerosene emulsion will destroy the fleas upon them.

Contribution from the Bureau of Entomology
HOWARD, Chief

Washington, D. C.

Issued November 8, 1915, as No. 683
Second revision, June, 1921

FLEAS AND THEIR CONTROL.

CONTENTS.

	Page.
Life history and habits	3
Length of life of the adult	5
Abundance of fleas, with relation to season, climate, and other conditions	5
Fleas as pests in the household	6
Fleas injurious to poultry and domestic animals	7
The sticktight flea	7
Dog and cat fleas	8
The relation of fleas to bubonic plague	9
Means of repression	10
Remedies for household infestations	10
How to kill fleas on cats, dogs, and hogs	10
Control of hosts	11
How to destroy fleas in immature stages	11
Trapping fleas	13
Isolating and repelling	14
Methods of controlling the sticktight or chicken flea	14
Treatment of flea bites	15

FLEAS AFFECT US IN TWO WAYS: First, as disease carriers, and, second, as parasites or annoyers of man and animals. The dread bubonic plague has been found to be transmitted largely, if not entirely, through the agency of these insects. A disease known as infantile kala azar, occurring in the countries bordering the Mediterranean Sea, is probably also transmitted by them, and a species of tapeworm which infests dogs and occasionally people has been found to pass at least one stage in the dog flea and then to gain entrance to a new host by the swallowing of crushed or living fleas. The recent war, with its movement of vast bodies of troops between various parts of the world, had its attendant danger of spreading disease, and it is probable that the dangers along this line are just as acute now, owing to the unsettled conditions that prevail in various countries.

Aside from the transmission of diseases fleas are of considerable importance as parasites of man and animals. In many instances they have been known to render houses uninhabitable for a time, and certain species cause considerable loss among poultry as well as annoyance to other animals.

LIFE HISTORY AND HABITS.

Fleas are of many kinds. Most of them, however, are of no importance to man, as they feed on various wild birds and mammals. Nearly all species have some one host upon which they prefer to live, but they may feed upon other animals and often thrive upon them. For example, the dog flea (fig. 1)[1] normally feeds on dogs and cats, but when excessively numerous may prove a troublesome pest to man; the human flea normally attacks man, but may be found on a number of other animals; rat fleas, in the absence of their usual hosts, will bite man, and these fleas are the ones ordinarily responsible for the inoculation of man with bubonic plague.

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[1] The fleas mentioned in this bulletin are known scientifically as follows: Dog flea, *Ctenocephalus canis* Curtis; cat flea, *Ctenocephalus felis* Bouché; human flea, *Pulex irritans* L.; rat fleas, *Xenopsylla cheopis* Roth. (the Indian rat flea), *Ceratophyllus fasciatus* Bosc. (the European rat flea), and others; chigoe, *Dermatophilus penetrans* L.; sticktight or chicken flea, *Echidnophaga gallinaceus* Westw.

Fleas of different species vary markedly in the intimacy with which they are associated with their hosts. Some kinds remain upon host animals practically all the time. In fact, the chigoe flea normally buries itself in the skin of the host and there develops its eggs and dies. The sticktight flea, or chicken flea, has the habit of intimate association with the host, but does not bury itself in the flesh of the animal. Dog fleas ordinarily remain upon the domestic animals almost continuously throughout their existence, but are not attached and feed only at intervals. The human flea remains upon man but little, being elsewhere the greater portion of the time.

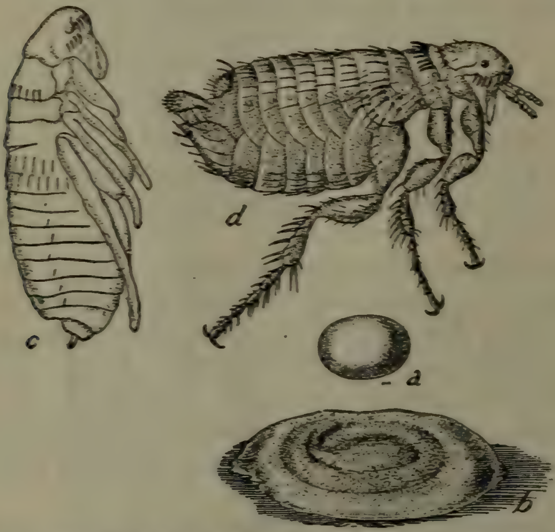

FIG. 1.—The dog flea: *a*, Egg; *b*, larva in cocoon; *c*, pupa; *d*, adult. *b*, *c*, *d*, Much enlarged; *a*, more enlarged. (Howard.)

The life of the flea has four distinct stages, as is the case with many other insects; these stages are the egg, larva, pupa, and adult.

A number of eggs are deposited by each adult female flea. The egg laying, alternated with feeding, extends over a considerable time. In most cases the eggs are deposited by the fleas while the latter are on the animal host, but as they usually are not cemented to the hair or feathers they fall out in the nest or resting place of the animal. The eggs are cream-colored or white and ovoid. Large numbers of them often may be seen on mats or cushions upon which infested dogs or cats sleep. Especially are they easily observed when on dark-colored cloths. Hatching usually takes place from 2 to 12 days after deposition.

The larva when first hatched is whitish, very minute, and quite active. (See fig. 2, larva of European rat flea.) In this stage fleas are not parasitic. They depend upon various animal and vegetable débris, including the excrement of the adult fleas, for food. During their growth the skin is shed twice, and between four days and several months after hatching a silken cocoon is spun, and in this the larva transforms to the pupa or resting stage.

The insect remains within the cocoon for a period which may range from three days to more than a year.

The complete life cycle of members of this group of insects may be passed in as short a period as 17 days, but during cool weather or under adverse conditions the total period from egg to adult may extend considerably over a year.

LENGTH OF LIFE OF THE ADULT.

The length of life of the mature flea varies much as between different species and under different atmospheric conditions. During hot, dry weather, and when no animals upon which to feed are present, the duration of life may be extremely short—from two to five days. When allowed to feed on blood, which is the only food taken by the adults, they may live from a month to almost a year. During summer probably the average longevity of the human flea without food is about two months, of the dog flea somewhat less, and of the sticktight flea still less.

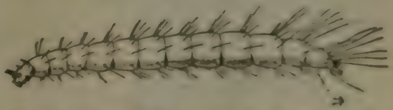

FIG. 2.—The European rat flea: Larva. Greatly enlarged.

ABUNDANCE OF FLEAS, WITH RELATION TO SEASON, CLIMATE, AND OTHER CONDITIONS.

In the northern part of the United States nearly all fleas pass the winter in the immature stages, while in the more southern latitudes some of them are present on hosts throughout the winter months. In general, however, these insects are never as abundant during winter and spring as they are in summer and fall. In the extreme Southern States this is not always true, as much trouble from the human, dog, and sticktight fleas has been observed to occur in late spring or early summer when rains were frequent and the humidity high.

Rainfall and the amount of moisture in the atmosphere have much to do with flea breeding. As a rule rainy summers are productive of outbreaks of fleas, and extremely hot, dry weather tends to check their breeding. The larva and pupa require a certain amount of moisture for successful development, and the adults live longer when a proper degree of moisture is present. It would be erroneous, however, to infer from this that fleas require very moist places in which to breed; in fact excessive moisture in the breeding places is as detrimental as is excessive dryness. This sensitiveness to excessive moisture can be utilized in remedial work, as will be pointed out later.

It is common knowledge that fleas occur in greatest abundance in sandy regions. This is explained by the fact that sand maintains moisture more uniformly, and thus permits the immature stages of the flea to develop with greater success. The sand also offers some protection to the adults and renders heavy rains less destructive to all stages of the flea present on the soil.

FLEAS AS PESTS IN THE HOUSEHOLD.

As has been pointed out,[1] in the eastern part of the United States the dog flea is the species of greatest importance as a household pest. Many instances have been brought to the attention of the Bureau of Entomology in which houses, particularly those vacated for some time during the summer months, have been found to be literally overrun by the pests.

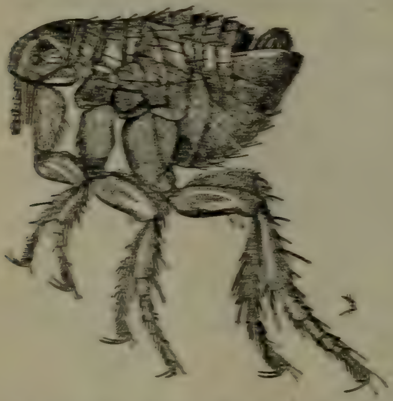

FIG. 3.—The human flea: Adult male. Greatly enlarged. Note the difference in the shape of the abdomen of the male as compared with that of the female (title-page).

In portions of the South and West the human flea (title-page illustration and fig. 3) is the one primarily responsible for house infestations. Although the host relationship of these two species is somewhat different, the same methods of control are applicable, for the most part, to both. When comparatively small numbers of fleas are found on people in houses, breeding places should be sought out of doors in sheds or barns frequented by dogs and cats, especially if the house is kept clean and animals do not frequent it.

The conditions which give rise to severe outbreaks in houses, particularly in the case of the dog or cat fleas, are usually these: Pet dogs or cats are kept about the household during the spring and early summer, and great numbers of eggs are deposited upon them by the fleas. These eggs are scattered about the floors and soon hatch into minute maggots which feed upon the vegetable and animal matter under carpets and mattings and in cracks. During this time the house may have been closed up during a vacation period and the breeding allowed to proceed unchecked, so that at about the time the occupants return the fleas have reached the adult stage. In the absence of other hosts they are exceedingly hungry and ready to attack man or any animals which are accessible.

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[1] Howard, L. O. House Fleas. U. S. Dept. Agr. Bur. Ent. Cir. 108, 4 p., 2 figs., Feb. 11, 1909.

Some infestations of residences come from breeding places beneath the houses. The fleas in these cases usually are furnished by stray animals which sleep under the buildings. The immature stages develop in the accumulation of dust and vegetable matter in the beds of these animals. Instances are not uncommon in which such infestations have extended to lawns, barnyards, and, in fact, all over the premises, although as a rule the center of infestation is in some one definite place frequented by animals.

The infestations of the human flea are usually less severe than in the extreme cases above mentioned, and the breeding places often are more widely extended.

A number of instances in the Southern and Central Western States have come to notice in which hogs appear to have been the source of gross infestations by the human flea. The adult fleas feed on the hogs and breeding takes place in the beds of these animals. In some instances the source of infestation is in the hog runs, but more usually it is derived from hogs sleeping under houses or in barns.

FLEAS INJURIOUS TO POULTRY AND DOMESTIC ANIMALS.

Fortunately the higher domestic animals are comparatively free from flea attacks. Horses, cattle, sheep, and goats are seldom seriously annoyed, although a few instances have been noted in which the sticktight flea infested horses, and mules and horses are sometimes worried considerably by the human flea and may refuse to stay in infested barns even long enough to eat. Hogs are infested to some extent, but seldom heavily enough to do any great damage.

THE STICKTIGHT FLEA.

The sticktight flea, or southern chicken flea (figs. 4, 5), probably is the most important of our live-stock infesting species. This form attacks a number of different hosts, including poultry, dogs, cats, and some wild animals. As has been stated, the adult fleas remain during the greater part of their lives attached to the host animal. On dogs and cats they are largely found on the ears, particularly along the edges. In the case of poultry infestations fleas are most common on the heads of the hosts, where they are to be seen in groups or patches. This habit of attaching in clusters seems to be well marked, and an infested fowl often may be recognized at a considerable distance by the dark flea-covered areas about the eyes, comb, and wattles. Figure 4 illustrates the usual mode of infestation on a chicken's head, and figure 5 shows one of the fleas much enlarged. When the fleas are excessively abundant they may be found in similar patches on the neck and various parts of the body.

This flea is most common and is of greatest importance in the Southern and Southwestern States. It has been reported as injurious to poultry as far north as Kansas. The injury is most marked in young chickens, which when fairly heavily infested often die quickly.

Older fowls are more resistant, but have been known to succumb to very heavy infestations; and certainly the fleas materially reduce the egg production, retard the growth of fowls, and diminish their size.

The eggs are deposited by the adult flea while it is attached to the host. They fall to the ground under the roost in chicken houses or under sheds frequented by the poultry and there continue to develop. When dogs and cats are infested, the immature stages develop largely in the material used by them for beds. They require comparatively dry material in which to breed, but a large amount of air moisture is favorable to them. Adults of this species continue to emerge from infested trash for four or five months after all hosts have been removed; hence it is easy to understand why chicken houses may still have many fleas in them after being unused for considerable periods.

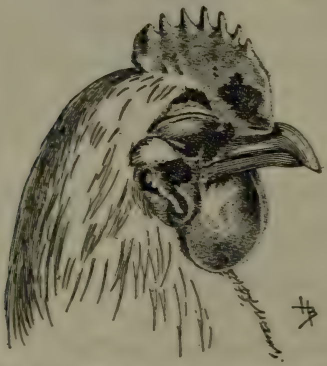

FIG. 4.—Head of rooster infested with the sticktight flea. Reduced.

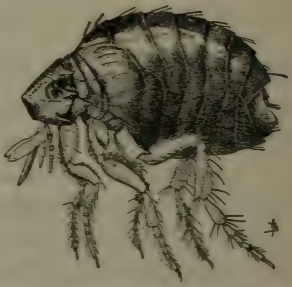

FIG. 5.—The sticktight flea: Adult female. Much enlarged.

A few other species of fleas are occasionally found in poultry houses. Some of these may be normally bird-infesting species, while others are at home in the houses of domestic poultry. Infestations by these fleas have been reported from several places in the Northern States, particularly in the Northwest. The presence of the fleas is usually first detected by persons entering chicken houses and being attacked by them. These fleas do not remain attached to the host continuously as does the sticktight flea. They are seldom of any great importance and may be controlled by the methods outlined on pages 10–14.

DOG AND CAT FLEAS.

Dogs and cats are infested by two very closely related species of fleas,[1] and these appear to feed more or less interchangeably on the two hosts, as well as occasionally on man and other animals. While they cause these hosts much annoyance and, as has been pointed out, are also responsible for the infestation of dogs by tapeworms, serious injury seems to be rare. In the case of valuable dogs and cats, however, it is often desirable to rid them of fleas, and in all cases where these animals are closely associated with man the control of the fleas upon them is of importance. As will be seen by comparing figure 1 with figure 5 the dog flea is quite different from the sticktight flea in structure as well as in size. The adults do not remain attached to the host in one place, but the life history is not vastly different from that of the sticktight flea. Breeding takes place in similar materials in situations occupied by the host animals. Mr. Theodore Pergande, working with the dog flea at Washington, D. C., found the life cycle from egg to adult to be completed within 17 to 37 days. It is thus seen that a great number of fleas might be produced in and beneath an unoccupied house in a comparatively short period.

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[1] The cat flea is known scientifically as *Ctenocephalus felis* Bouché and the dog flea as *Ctenocephalus canis* Curtis. The human flea also is not uncommonly found on dogs and cats.

Both of these species have a very wide distribution, being found in practically all parts of the world where dogs and cats are found.

THE RELATION OF FLEAS TO BUBONIC PLAGUE.

During recent years bubonic plague has been introduced into the United States on both the Pacific and Gulf Coasts. The infestation in California has persisted for a number of years, although closely held in check through the efforts of the Public Health Service and the State board of health. The disease around San Francisco not only persisted among the rats, but gained a foothold among ground squirrels in the counties adjacent to San Francisco Bay.

During the year 1914 the disease broke out in New Orleans, but strict quarantine measures and an energetic campaign against the rats[1] kept the malady from spreading and limited the number of human cases.

With the reduction in numbers of rats and mice there is a correspondingly great decrease in the numbers of the species of fleas which infest them and which may play a part in carrying bubonic plague. The cleaning up of the breeding places of rats and the destruction of their nests will accomplish the extermination of a large number of fleas in the immature stages.

Persons resident in districts where plague occurs among the ground squirrels should remember that there is danger of infection from the bites of fleas which infest these animals.

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[1] The methods of rat control are discussed in Farmers' Bulletin 896, U. S. Department of Agriculture, by Mr. D. E. Lantz, of the Bureau of Biological Survey.

MEANS OF REPRESSION.

Certain general principles regarding the control of fleas are applicable to nearly all species, but some modifications of the methods employed are necessary for different species, and under the different conditions in which they exist.

REMEDIES FOR HOUSEHOLD INFESTATIONS.

As has been pointed out, the dog flea and the human flea are the two most important species invading the habitations of man. It has also been suggested that the adult fleas feed more or less on cats and dogs and that the immature stages develop in the cracks of floors and beneath houses. It therefore is apparent at once that two steps are necessary to cope with the pest: (1) The destruction on the host of the adults which are producing the eggs, and (2) the clearing out of the immature stages which are breeding in or under the house.

HOW TO KILL FLEAS ON CATS, DOGS, AND HOGS.

One of the most successful methods of killing fleas on cats and dogs is to wash the animals thoroughly in a tub containing the proper proportion of a saponified coal-tar creosote preparation, of which there are a number on the market, known as "stock dips," etc. The animal should be scrubbed thoroughly, special precaution being taken that the fleas on the head are well soaked, as many rush there to get away from the parts that are covered with the solution. After the animal has been in the bath for about 5 or 10 minutes it may be removed and allowed to dry. In the case of cats, especially if tender skinned, the preparation should be washed out of the fur with soap and warm water soon after the animal is taken out of the solution.

In addition to the destruction of all fleas present, this washing cleanses and deodorizes the fur and also aids in the healing of any wounds which are present.

The thorough washing of infested animals in kerosene emulsion is a cheap and satisfactory method of destroying fleas. Five gallons of this emulsion may be made by dissolving 2 ounces of washing soap in 1 quart of hot water and when brought to a boil removing it from the fire and adding 2½ pints of kerosene. The mixture should be agitated violently with an egg-beater or something of the sort. This should result in a milky mass from which the oil does not separate. Water is then added to make 5 gallons. Free kerosene will burn animals, and if any separates out the mixture should be reheated, care being taken to avoid spilling it on the fire or boiling it over, and then it should be beaten again.

Other methods of destroying fleas on cats and dogs have been recommended. Among these the careful rubbing into the hair of powdered naphthalene or moth balls has been found effective. Pyrethrum or Persian insect powder is used in the same way. Both of these materials stupefy the insects and cause them to come to the surface of the hair or actually drop out. The animals should be treated on papers spread on the floor and the insects burned after the dusting is completed.

Recent experiments with the use of the powdered roots of certain tropical plants known as derris indicate that this drug when fresh is exceedingly effective in destroying fleas on animals. All fleas on a dog will be destroyed by one application of 1 gram or about three-fourths of a level teaspoonful of the powder. It is suggested that the material be mixed at the time it is used with two parts of flour or cornstarch and dusted into the hair of the animal, especially along the back and neck, with a shaker.

The skin of cats is much more easily injured with chemicals than that of dogs; hence, any preparation used should be weaker when used on cats than on dogs.

Fleas on hogs may be destroyed by dipping the animals in a vat containing one of the creosote dips used for the hog louse or by sprinkling crude petroleum on them when they are eating.

CONTROL OF HOSTS.

In order to avoid the infestation of houses, it is important that all animals be kept from beneath dwellings. In such situations breeding may progress rapidly, and it is very difficult to treat the breeding places. If fleas are continuously annoying about the household, it is often desirable not to admit cats and dogs at all, but to provide regular sleeping quarters for these animals out of doors and prevent flea breeding by methods suggested in the following paragraph. Stray cats and dogs should not be encouraged about the premises. In towns and cities the enforcement of the dog-tax law and the destruction of all untagged animals will tend greatly to reduce house infestations. It is also desirable to keep different kinds of animals which are subject to flea infestation separated, and care should be exercised that infested animals are not brought to clean premises and that infested poultry are not placed with a clean flock.

HOW TO DESTROY FLEAS IN IMMATURE STAGES.

Following the ridding of infested animals of adult fleas, it is important to destroy the immature fleas, which are constantly becoming full grown and reinfesting animals and annoying man.

When adult fleas are very numerous it is advisable to kill them before proceeding to destroy the young. Experiments of a practical nature prove that very striking results may be accomplished by the spraying of an infested area, whether in a basement, chicken house, barn, or feed lot, with creosote oil. A light spraying kills the adult fleas almost instantly and apparently has some destructive effect on the immature stages.

Creosote oil is derived from coal tar and is used as a wood preservative. It is comparatively cheap, retailing at about 50 cents per gallon. Unfortunately it is not generally available at present and it is somewhat variable in composition, especially in regard to the amount of tar acids present. The best results are secured with a product containing from 12 to 20 per cent tar acids. Where there is grass or shrubbery to be considered, kerosene emulsion should be substituted for the creosote oil, which will kill vegetation. Care should also be taken not to strike animals directly with the material, as it is rather caustic. In houses the use of flaked naphthalene as described in a later paragraph will permit the work of cleaning to proceed without annoyance from adult fleas.

In household infestations usually it is found that the breeding takes place in the cracks of floors or beneath carpets or in rooms which are not frequently swept, but which may be visited by pet dogs and cats. The carpets and rugs should be removed, the floors thoroughly swept, and all of the dust thus obtained burned, as it contains many of the eggs and maggots of the fleas. Then the floor should be scrubbed with strong soapsuds or sprinkled with gasoline, care being taken to avoid having fires about during the procedure. After the floor coverings are thoroughly aired and beaten they may be returned, but it is desirable before putting them down to sprinkle the floor with naphthalene crystals or pyrethrum powder.

In flea-infested regions it is advisable to avoid the use of mattings and carpets. These may be supplanted by rugs or oiled floors, which facilitate frequent sweeping and make the destruction of the immature stages easier if an infestation becomes established.

Among other methods for destroying the fleas in houses the following have been tried and recommended: Scatter 5 pounds of flake naphthalene over the floor of an infested room and close the doors and windows tightly for 24 hours. After this period the naphthalene may be swept into another room, and so on, thus making the treatment inexpensive. The free use of alum, both in the powdered form sprinkled over carpets and rugs and by dipping papers in an alum solution and placing them under the rugs, is said to give satisfactory results. The fumigation of houses with sulphur fumes or hydrocyanic-acid gas kills all fleas present and in addition destroys the rats and mice. When sulphur is to be employed the infested building should be closed up tightly and the material used at the rate of 4 pounds to each 1,000 cubic feet of space. If the immature stages have been destroyed by the methods mentioned, 2 to 3 pounds of sulphur per 1,000 cubic feet of space will be sufficient to destroy the adults. The sulphur is made into a cone-shaped mass in a good-sized pan or kettle and placed in a larger pan containing water to avoid danger of fire from the heat generated. As sulphur will not burn readily at first a little alcohol is poured into a depression made in the top of the cone, and a match applied. Each room should have a pan of sulphur, and the rooms should be kept closed about 12 hours. As the gas generated from burning sulphur corrodes metals and injures plants, it is necessary to remove metal objects and potted plants before fumigation. It is not advisable for anyone to undertake the use of hydrocyanic-acid gas without obtaining the complete directions for its employment contained in Farmers' Bulletin 699, entitled "Hydrocyanic-Acid Gas Against Household Insects." This gas is very poisonous, but it is one of the most satisfactory for destroying all sorts of vermin in buildings.

When house infestations are derived from fleas which breed beneath or around houses, the first step is to clean out all the loose material in which fleas may be breeding and burn it. Then common salt should be scattered about and thoroughly wet down. A second wetting two or three days later usually will accomplish complete destruction, but if this is not found sufficient, one or two additional wettings may be given. Where crude petroleum is cheap and especially where water can not be applied easily, sprinkling the ground with a liberal amount of this oil will give good results. The free use of lime on the cleaned areas also apparently destroys many immature fleas. In exceptional cases lawns become infested, and fleas breed out around the roots of the grass. It is impracticable to apply chemicals in such situations, but much may be done to check the breeding by cutting the grass exceedingly short and thus exposing the young fleas to the heat of the sun, which will usually accomplish their destruction. In certain sections it has been found feasible to destroy flea infestations in barns and hog runs by diking the infested areas and pumping water in so as to flood them entirely.

TRAPPING FLEAS.

Following the treatment of host animals and the thorough cleaning up of the premises, as has been outlined, many of the remaining adult fleas may be caught by the use of traps.

There seems to be some virtue in the use of lights at night for attracting the adult fleas. A small lamp set in a pan of water covered with a film of kerosene may be used for this purpose.

It has been found that a considerable number of fleas may be collected about a room or cellar by allowing an animal such as a guinea pig or cat to be free in the room. The fleas thus concentrated on the animal may be destroyed by the methods mentioned under the heading, "How to kill fleas on cats, dogs, and hogs" (p. 10). In districts where the plague is known to exist and it is desirable to catch the few fleas about the premises, this method is of some value.

ISOLATING AND REPELLING.

It has been determined that the greatest horizontal distance fleas can jump is about 13 inches, and they can not jump more than one-half of this distance vertically. It is possible, therefore, to prevent them from gaining access to a bed by placing sticky fly paper about 13 inches wide on the floor around the bed, provided fleas are not breeding out under it. It is also possible to keep fleas out by placing the legs of the bed in pans of water covered with a film of kerosene, if the bedding is prevented from reaching near the floor.

Many different substances have been advocated as repellents for fleas. Among these may be mentioned such plants as pennyroyal and boughs and chips of pine. Naphthalene crystals and pyrethrum have also been employed for dusting between the sheets in order to repel the fleas from bedding, and these substances, as well as oil of pennyroyal and oil of tar, may be used about the household to drive out the fleas.

It should be borne in mind that the methods of trapping and repelling just discussed are secondary to the more important measures of destroying the breeding places and freeing hosts from fleas.

METHODS OF CONTROLLING THE STICKTIGHT OR CHICKEN FLEA.

Many of the suggestions for controlling fleas in the household are applicable to the sticktight flea. As has been pointed out, this species breeds largely in chicken houses and adjacent buildings frequented by the fowls, although dogs and cats may be important sources of infestation.

As a preliminary step it is well to see that the poultry are kept away from other animals as far as possible. Especial care should be exercised to keep dogs and cats from lying about the chicken yards or places frequented by the poultry. All animals, and the poultry as well, should be excluded from beneath houses and barns, as such places are favorable for flea development and difficult to treat if they become infested. These precautions should be followed by a thorough cleaning out of the chicken house and outbuildings frequented by the poultry. All of the material should be hauled a good distance from the buildings and scattered. The places where the fleas are thought to be breeding should then be sprinkled with crude oil. This species can not thrive in damp places, and if the sprinkling is done two or three times a week no further breeding is possible. One of the most satisfactory methods of preventing breeding is to scatter salt freely about the chicken house and then wet the soil down thoroughly. *Fowls should not be permitted to eat the salt, as it is poisonous to them.*

It is rather difficult to destroy the sticktight flea on fowls without injuring the host. It is desirable, however, in the case of heavy infestations to destroy as many of the fleas as possible. This may be accomplished by carefully applying carbolated vaseline to the clusters of fleas on the fowls, or greasing them with kerosene and lard—1 part kerosene to 2 parts lard. In all cases care should be taken that the applications of grease are confined to the seat of infestation. It is important that dogs and cats be freed from sticktight fleas. This may be accomplished by washing them in a saponified coal-tar creosote preparation, as has been described, or by greasing the most heavily infested parts with kerosene and lard. Rats sometimes harbor these fleas in considerable numbers, therefore their destruction will aid in the control work as well as doing away with another troublesome chicken pest.

The thorough cleansing of poultry houses and runs and the application of crude petroleum will be found to aid in the control of other important enemies of fowls, such as mites and chicken ticks or "blue bugs."

TREATMENT OF FLEA BITES.

In regions in the United States where the plague is not known to occur no special concern need be felt regarding flea bites. When feeding, the fleas inject a salivary secretion which tends to produce inflammation at the site of the puncture. Usually the bites result in small inflamed spots, but occasionally, where the pests are very numerous and in the case of susceptible individuals, more general inflammation may occur, sometimes followed by swelling and, occasionally, especially after scratching, by ulceration.

Those who are especially annoyed by the bites will find that various cooling applications will give relief. A 3 per cent solution of carbolic acid in water applied to the bites will be beneficial, and such substances as menthol, camphor, and carbolated vaseline will be found to allay the irritation. Iodine in the form of a tincture, if applied to the bites, will alleviate the irritation, but should not be used by persons afflicted with any form of eczema, or applied to the tender skin of young children, as it may stimulate the eczemic eruptions or blister the skin, causing undue annoyance.

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STANDARD VARIETIES OF CHICKENS

II. THE MEDITERRANEAN AND CONTINENTAL CLASSES

ROB R. SLOCUM
Of the Animal Husbandry Division

SUPERSEDED BY 1506

FARMERS' BULLETIN 898

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Animal Industry
JOHN R. MOHLER, Chief.

Washington, D. C.

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CONTENTS.

Page.
Importance of egg production 3
Characteristics of the egg breeds 3
Breeds and varieties 7
  Leghorn 6
  Minorca 15
Breeds and varieties—Continued.
  White-faced Black Spanish 19
  Blue Andalusian 20
  Ancona 22
  Campine 24

IMPORTANCE OF EGG PRODUCTION.

EGG production doubtless is the leading branch of poultry keeping, and, in addition, is a very important agricultural activity. According to the last census the eggs produced in the United States in 1909 numbered more than 1,591,000,000 dozen, with a value of more than $306,000,000. Eggs, of course, are produced wherever chickens are kept, and by far the greater part of the egg crop comes from the general farm, yet large so-called egg farms have been developed with the main purpose of producing eggs for market. The largest of these egg farms and the greater number of them are located near markets which pay a premium for white eggs; and for this reason, together with the fact that eggs are primarily desired, the breeds kept are those known as the egg breeds, such as the Leghorn, Campine, Minorca, and Ancona. The Single Comb White Leghorn is undoubtedly the most popular and the most widely kept variety of the egg breeds. These breeds comprise the Mediterranean and Continental classes, as given in the American Standard of Perfection. The egg breeds frequently are found on general farms also, particularly in those sections near markets preferring a white egg, and where considerable flocks of poultry are kept.

CHARACTERISTICS OF THE EGG BREEDS.

These breeds are smaller than the general-purpose breeds, such as the Plymouth Rock, and for that reason they do not make a particularly desirable table fowl and are not in as good favor with the poultry packers as the larger general-purpose breeds. Surplus cockerels, however, turned off as broilers when they weigh from three-quarters of a pound to a pound and a half, find a ready market.

The egg breeds in general are characterized by their activity and sprightliness, and are of a much more nervous temperament than the heavier breeds. It is necessary to work and move quietly among them to avoid frightening them. They are more difficult to keep in confinement, and where their quarters are fenced, 6 or 7-foot fences are used. Clipping the flight feathers of one wing will keep them from flying over the fence. They mature more quickly than the heavier breeds, but if hatched early, they often begin to lay so early in the fall that they go into a molt like the old hens. This of course checks their egg production. It is the custom of some egg farmers to hatch early chicks for the purpose of obtaining eggs during the fall, expecting these early birds to go into a molt and depending upon later hatches to supply eggs during the late fall and winter.

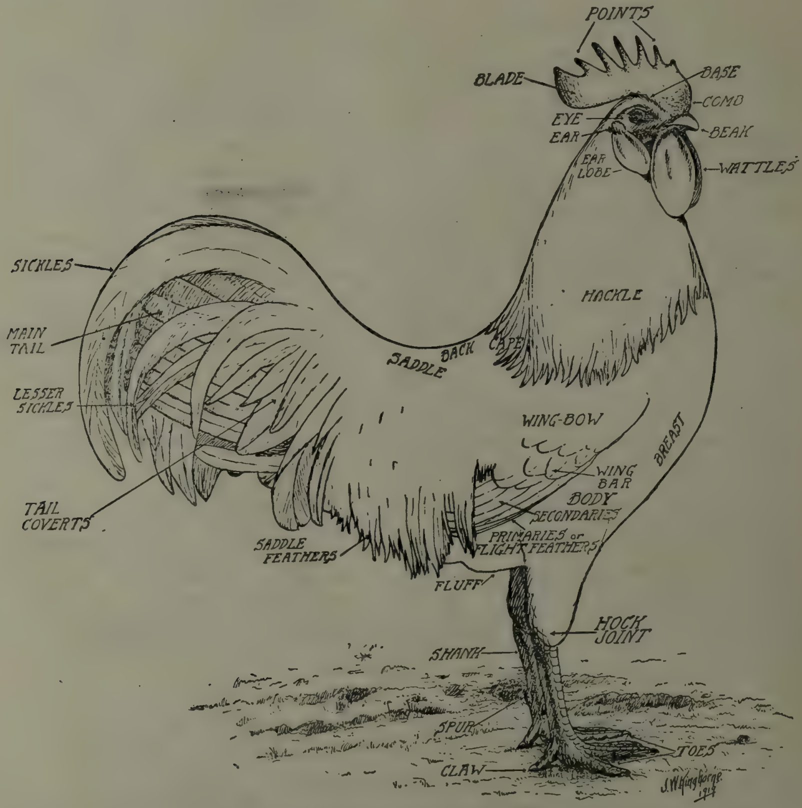

Fig. 1.—Glossary chart giving the names of the various parts of a male fowl.

Chickens of the egg breeds, because of their greater activity, are fine foragers, and when they have free range they will cover a very

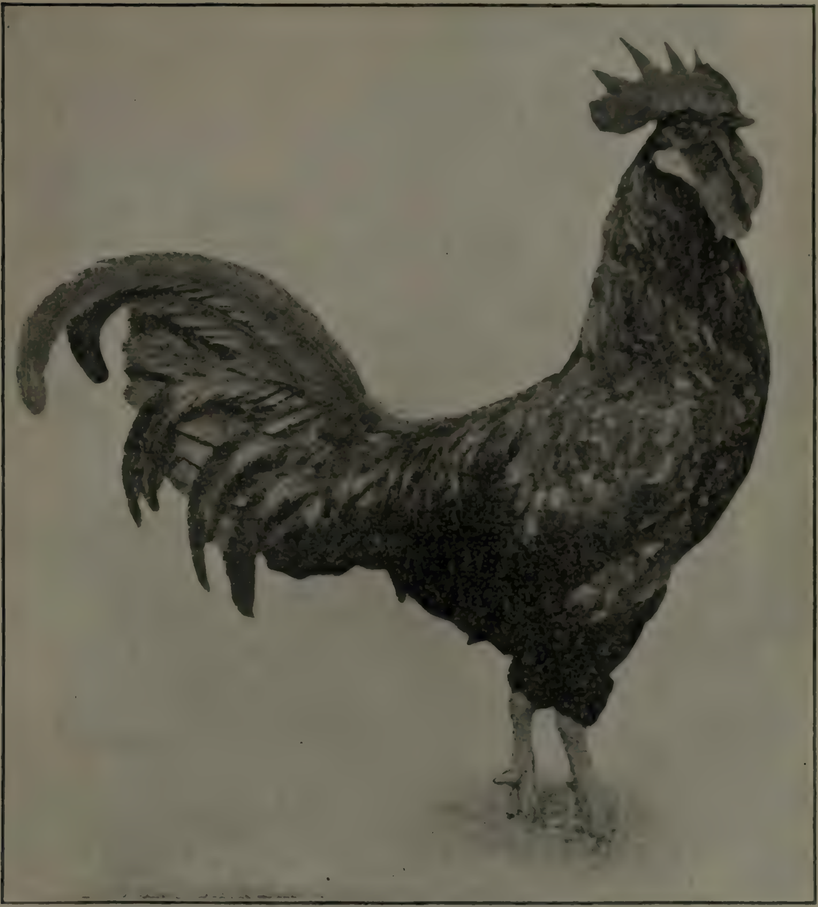

FIG. 2.—Single Comb Dark Brown Leghorn, male.

large area and pick up a considerable amount of feed. Fowls of these breeds do not have the same tendency to become overfat as fowls of larger breeds, and though they respond to careful feeding they are not so quick to feel the bad effects of overfeeding. Because of their smaller size they do not eat as much as fowls of the larger breeds.

All of the egg breeds are classed as nonsitters—that is to say, they do not become broody and hatch their eggs. Occasional individuals will show broodiness, and will even bring off a hatch of chicks; but they are not dependable for this purpose. Where egg breeds are kept it is therefore necessary either to depend upon hatching with incubators and brooding with heated brooders or else to keep hens of a broody breed for the purpose of hatching and brooding the chicks.

All of the egg breeds are clean legged, or have shanks free from feathers, and have white or creamy-white ear lobes. They are close-feathered fowls, being tighter in this respect than the Plymouth

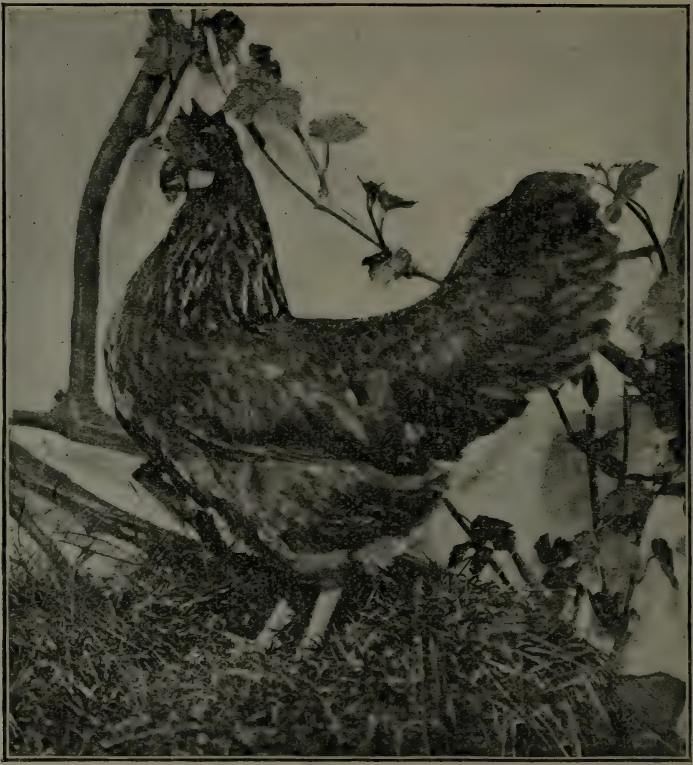

FIG. 3.—Single Comb Light Brown Leghorn, female.

Rocks, but not so tight as the Games. All of them also lay white eggs of good size, and as a class they are reputed to be excellent layers.

BREEDS AND VARIETIES.

The Mediterranean class includes the following standard breeds and varieties:

BREEDS.	VARIETIES.
Leghorn	Single Comb Light Brown.
	Single Comb Dark Brown.
	Rose Comb Light Brown.
	Rose Comb Dark Brown.
	Single Comb White.
	Rose Comb White.
	Single Comb Buff.
	Rose Comb Buff.
	Single Comb Black.
	Silver.
	Red Pyle.
Minorca	Single Comb Black.
	Rose Comb Black.
	Single Comb White.
	Rose Comb White.
	Single Comb Buff.
Spanish	White-Faced Black.
Blue Andalusian.	
Ancona	Single Comb.
	Rose Comb.

The Continental class includes the following standard breed and varieties:

BREED.	VARIETIES.
Campine	Silver.
	Golden.

In describing these breeds and varieties it is the intention to give only a general statement of their appearance and characteristics. For a description sufficiently detailed to enable one to breed exhibition specimens it will be necessary to refer to the American Standard of Perfection, a book published by the American Poultry Association, which is the guide by which all the poultry shows in the United States are judged.

LEGHORN.

The Leghorn for years has been a widely known breed in the United States. Leghorns were brought into this country from Italy. The first varieties imported were the Single Comb Brown and the Single Comb White. There is every indication that this breed originated in Italy, where fowls of a similar type have been kept for many years. The breed is noted for its alertness, its stylishness of carriage, and the graceful blending of its different sections. In general the breed may be described as a rather small, comparatively long-backed chicken, with moderately low-carried, well-furnished and well-spread tail, and with a long, sweeping curve of neck, back, and tail. These birds have comparatively long shanks, are well up on legs, showing the hock and a part of the thigh. The body should

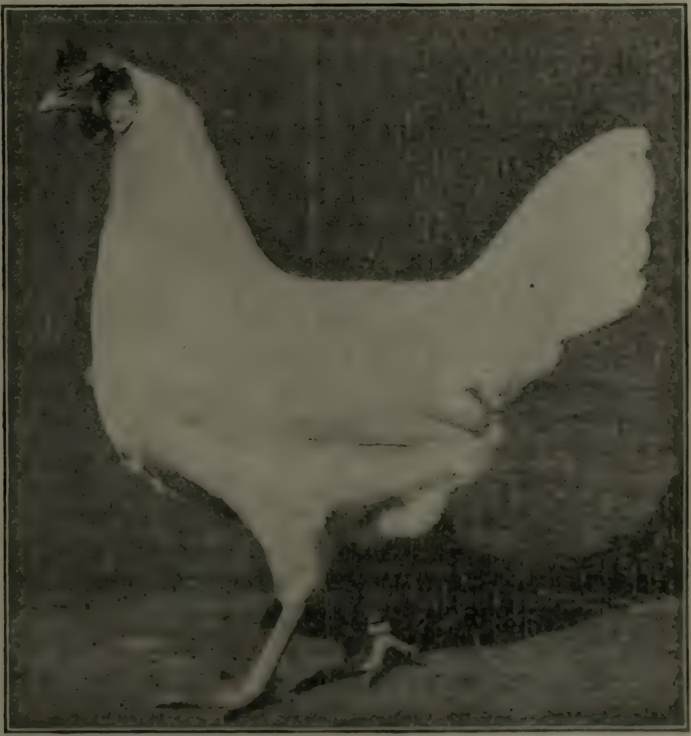

FIG. 4.—Single Comb White Leghorn, female.

be nicely curved throughout and the breast quite prominent. All the Leghorns have yellow skin and yellow shanks.

All the varieties of Leghorns are identical in size and type, differing only in kind of comb and in color. The single comb in the male should be of medium size and should stand erect, with five regular, deeply serrated points. The blade of the comb should extend straight out from the back of the head, and should not follow the curve of the neck or incline upward. In the female the front and the first point should stand erect, but the remainder of the comb droops to one side. The comb in both sexes should be free from wrinkles, thumb marks, or folds. In the Rose Comb varieties the comb of the male should be of medium size and square in front, well filled and free from hollows, the spike well developed and extending straight back off the head, showing no tendency to follow the curve of the neck or to turn upward. The rose comb of the female is small and neat, and in shape is like that of the male.

The standard weights are: Cock, 5½ pounds; hen, 4 pounds; cockerel, 4½ pounds; pullet, 3½ pounds.

The Single Comb Brown Leghorn is one of the older varieties of the breed known in this country. Until recently it was included in the standard as a single variety, but, owing to the almost universal practice of double mating, it has recently been divided into two varieties, known as the Single Comb Light Brown Leghorn and the Single Comb Dark Brown Leghorn.

By double mating is meant the use of two separate matings; one for the production of males of standard or exhibition color, known as the cockerel mating, and the other for the production of females of standard or exhibition color, known as the pullet mating. The present Single Comb Light Brown Leghorn consists of what was previously known as the pullet mating, while the Single Comb Dark Brown Leghorn consists of what was previously known as the cockerel mating. It is hoped that by dividing the Single Comb Brown Leghorn into the Light and Dark varieties double mating can be done away with.

The Single Comb Light Brown Leghorn male is one which is considerably lighter colored in all red sections than what was previously known as the standard colored male, now standard male of the Dark Brown variety. The base of the neck and the saddle should approach light orange in shade; the saddle should show no striping, and the undercolor throughout should be light slate instead of dark slate.

The female of this variety has a golden-yellow head which shows a tinge of dark brown. The hackle is golden yellow with a black stripe extending down the middle of each feather as in the Dark Brown Leghorn male, except that the stripe is broader and terminates in a rounder point. It is difficult to obtain females showing good hackles and at the same time good stippling, as the best-stippled females are likely to be weak in striping. The back, body, tail coverts, wing bows, and coverts have a surface color of light brown which is finely stippled with darker brown. The shade of color over the back, wing bows, and coverts should be even and the feathers free from shafting. The wing primaries are a slaty brown with the outer webs showing a narrow edging of brown. The secondaries are brown, with with the outer webs finely stippled with lighter brown. The tail is black, with the two highest main tail feathers stippled with lighter brown. The breast should be rich, clear salmon, free from penciling, stippling, or shafting. The sides of the breast shade gradually to the color of the wings. The fluff and thighs are slate tinged with brown. The undercolor throughout is slate.

The Single Comb Dark Brown Leghorn male has a dark-red head, a rich, red hackle and saddle, the feathers of which are striped with a greenish-black stripe extending through the middle of each feather. The back is of the same shade as the hackle, but is without the striping. The wing bows are rich red, the fronts and coverts greenish black, which show as a distinct wing bar when the wing is folded. The primaries are black, the lower webs edged with brown. The secondaries also are black, the lower webs showing edges of brown. The tail, body, breast, fluff, and thighs are black. The shanks are yellow, while the toes may be yellow or a dusky yellow. The undercolor throughout is slate.

The female of this variety is of a darker shade than the female of the Light Brown variety, formerly the only standard female. The back and wings should be of a darker color, in reality a black stippled with a dark brown. There should be no shafting, but the plumage should show a greenish sheen free from purple. The stippling is much coarser than is the case in the Light Brown female. The neck should be strongly striped with black. The breast is a dark-reddish salmon which is stippled with brown. The undercolor should be slate running quite dark clear to the skin. The legs and toes should be yellow, although a dusky yellow is allowable.

The Rose Comb Brown Leghorn under the old standard was identical in color and type with the Single Comb Brown Leghorn, the only difference being in the matter of the rose comb. When the Single Comb variety was divided into the Light and Dark varieties, the same action was taken with the Rose Comb variety. At present, therefore, there is a Rose Comb Light Brown Leghorn and a Rose Comb Dark Brown Leghorn which are identical in color and type with the corresponding Single Comb varieties.

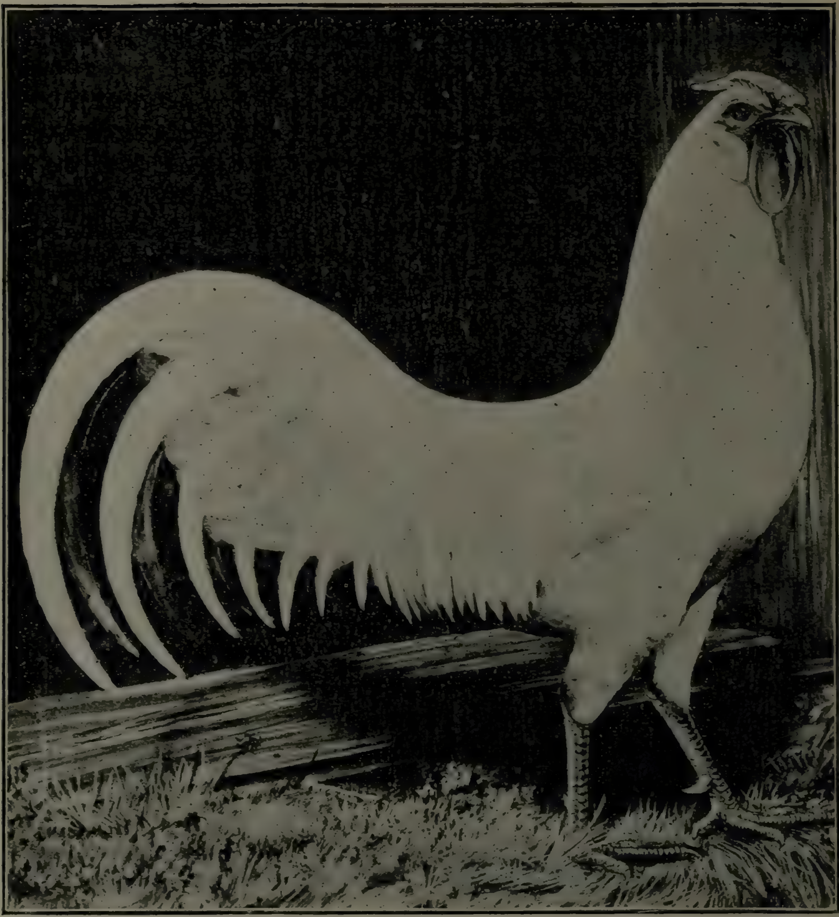

FIG. 5.—Rose Comb White Leghorn, male.

The Single Comb White Leghorn undoubtedly is the best known of the Leghorns or of any other variety of the egg breeds. It is widely kept, both on special egg farms and on general farms in certain sections of the United States. In some sections the keeping of White Leghorns has been developed on a large scale, and these sections may well be termed White Leghorn centers. The largest and best known of these centers are the districts around Petaluma, Calif., and Vineland, N. J. In type the Single Comb White Leghorn is identical with the Single Comb Brown Leghorn. In color both the males and females are white throughout, and should be free from any brassiness or creaminess. The shanks and toes should be a rich yellow. The male of this variety is shown on the title page and the female in figure 4.

The Rose Comb White Leghorn (figs. 5 and 6) is identical with the Single Comb White Leghorn except in the matter of the rose comb.

The Single Comb Buff Leghorn is a handsome and attractive variety, but is not so widely kept as either the Single Comb White or the Single Comb Brown Leghorn. The Single Comb Buff Leghorn is distinguished from the other Leghorns by the color alone. This should be an even shade of golden buff throughout. Shafting, or the presence of feathers having a shaft of different color from the rest of the feathers, and mealiness, or the presence of feathers sprinkled with lighter color as though powdered with meal, are undesirable. As deep an undercolor of buff as it is possible to obtain is desired. A very important point with regard to the surface color is to have the shade as even as possible throughout. The legs and toes are a rich yellow.

The Rose Comb Buff Leghorn is identical with the Single Comb Buff Leghorn except in the matter of the rose comb.

The Single Comb Black Leghorn (figs. 7 and 8) is distinguished from the other Single Comb Leghorns by the color alone, which is black in all sections, showing a lustrous sheen, free from purple barring. The undercolor throughout is a dull black. The legs and

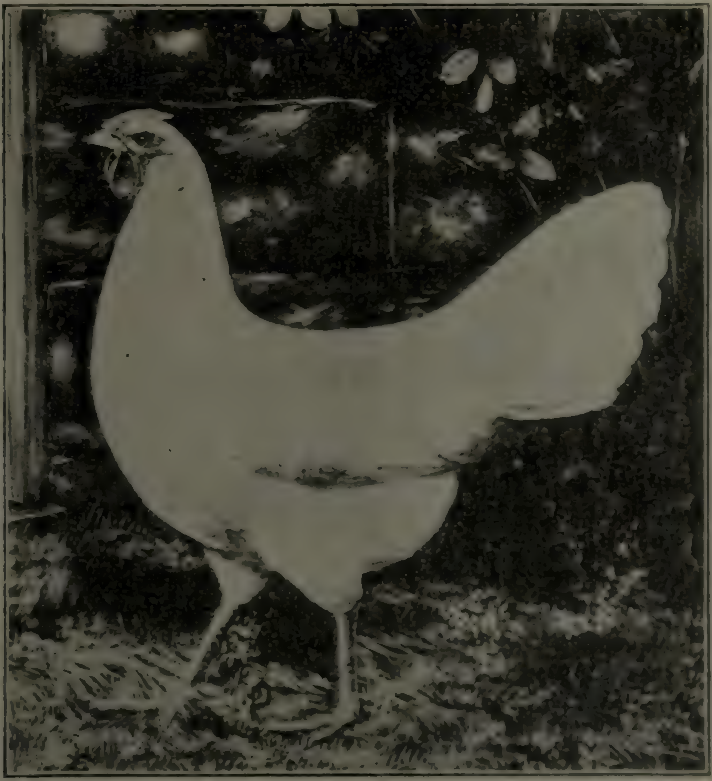

FIG. 6. Rose Comb White Leghorn, female.

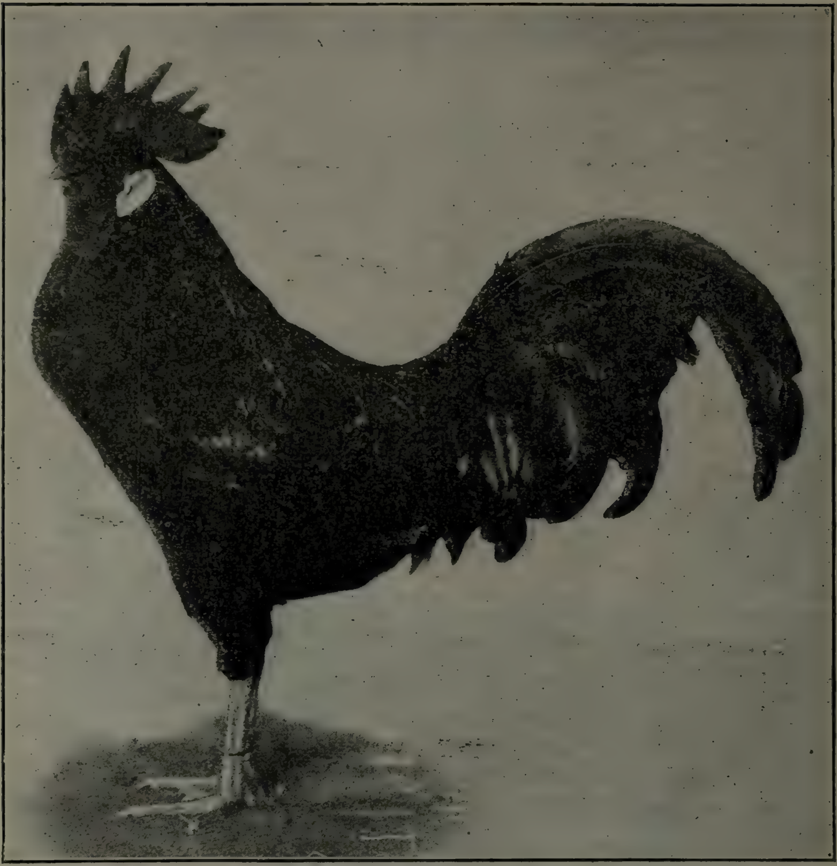

FIG. 7.—Black Leghorn, male.

toes are yellow or dusky yellow. The Single Comb Black Leghorn is a very attractive variety, but is not found very commonly.

The Silver Leghorn (figs. 9 and 10) is a single-comb variety of this breed and is identical in type with the other single-comb varieties. This variety also is most attractive in color but is not very commonly kept. The male has a silver top color. The head is silver white and the hackle is of the same color but with a median stripe of black. The wing fronts and shoulders are black, the bows a silver white, the coverts black and forming a distinct bar across the wing. The primaries are black except for the silver-white outer edges of the lower feathers. The secondaries are also black, but a part of the outer web is white in some of the feathers, forming a white wing bar. The back, saddle, and lower tail coverts are silver white. The cape, main tail feathers, sickles, upper tail coverts, breast, body, thighs, and fluff are black. The undercolor is gray throughout. In the

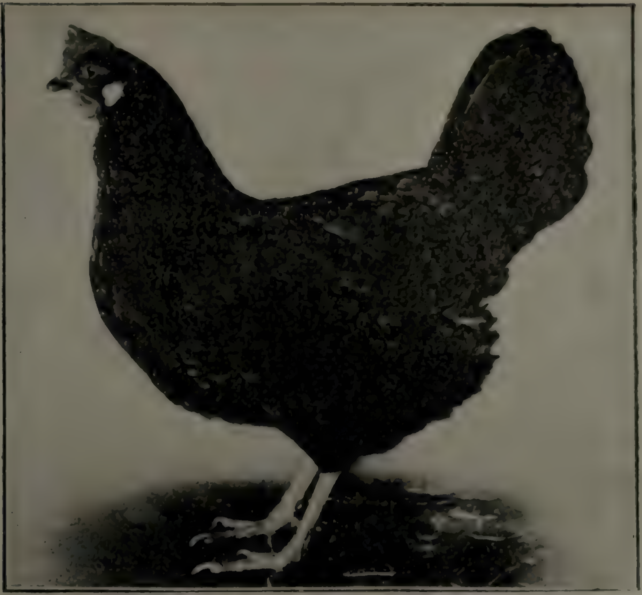

FIG. 8.—Black Leghorn, female.

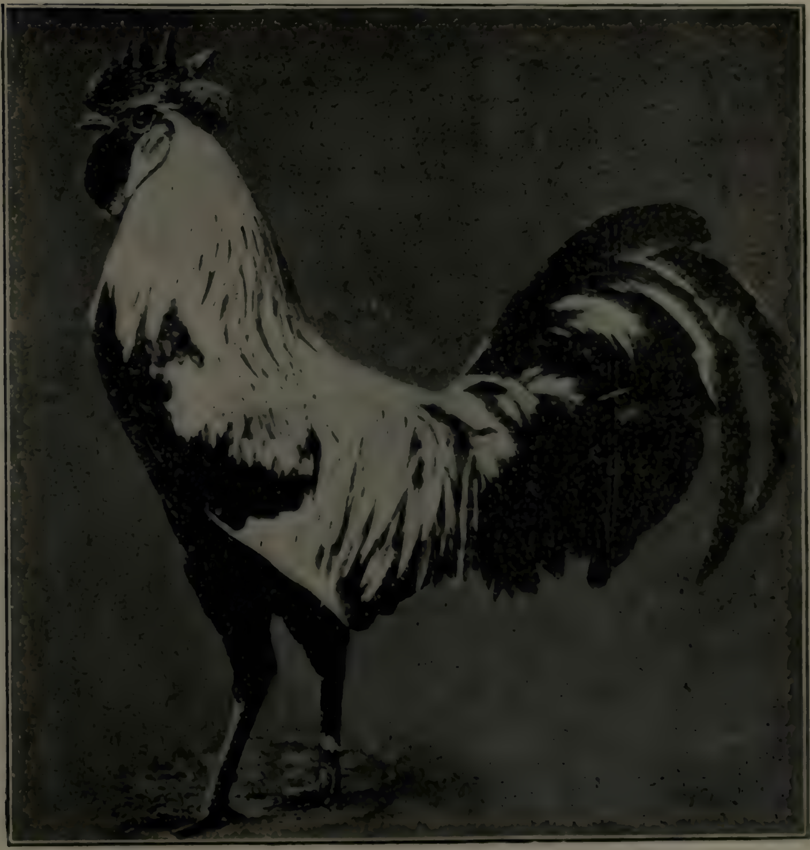

FIG. 9.—Silver Leghorn, male.

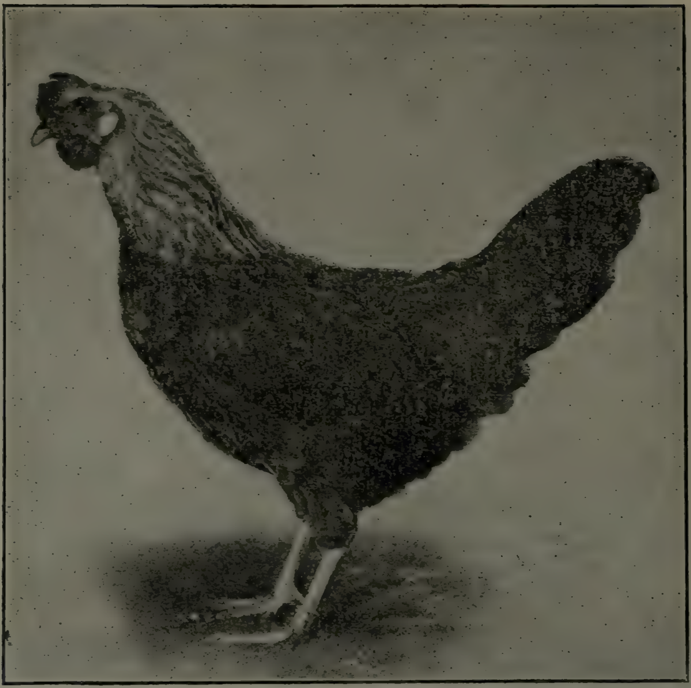

Fig. 10.—Silver Leghorn, female.

female the head is a silver gray. The neck is a silver gray, each feather showing a narrow black stripe. The wing bows and coverts are silver white, finely stippled with ashy gray, giving these sections a general gray cast. In the primary and secondary feathers the upper webs are gray and the lower webs slaty gray. The front of the neck is a light salmon, and the breast is salmon, fading gradually to the color of the wings at the sides. The back, body, and thighs are the same color as the wing bows and coverts. The tail is black except that the upper two feathers are light gray and the tail coverts are gray. The fluff is a light ashy gray. The undercolor is gray throughout. The legs and toes of both sexes are yellow.

The Red Pyle Leghorn also is a single-comb variety and is not very commonly found. In type this variety is identical with the other Single Comb Leghorns. The male is white with a red and orange top color. The head should show a bright orange, the hackle a light orange which may show some tinge of brighter yellow, the wing bows red, part of the outer web of the secondaries red, back red, and saddle light orange. The outer webs of the lower feathers of the primaries are bay. All other sections are white, and the undercolor is white throughout. In the female the color including undercolor is white throughout except for the head, which is golden, the hackle or neck feathers, which are white edged with gold, the feathers in front of the neck, which are white with a salmon tinge, and the breast, which is salmon. The legs and toes of both sexes are yellow.

MINORCA.

The Minorca appears to have been kept in Spain for a long time, and it is probable that the Minorcas found in this country came originally from that source. As the name would indicate, they are commonly supposed to have been natives of the island of Minorca. The importations to this country probably were from England rather than directly from Spain.

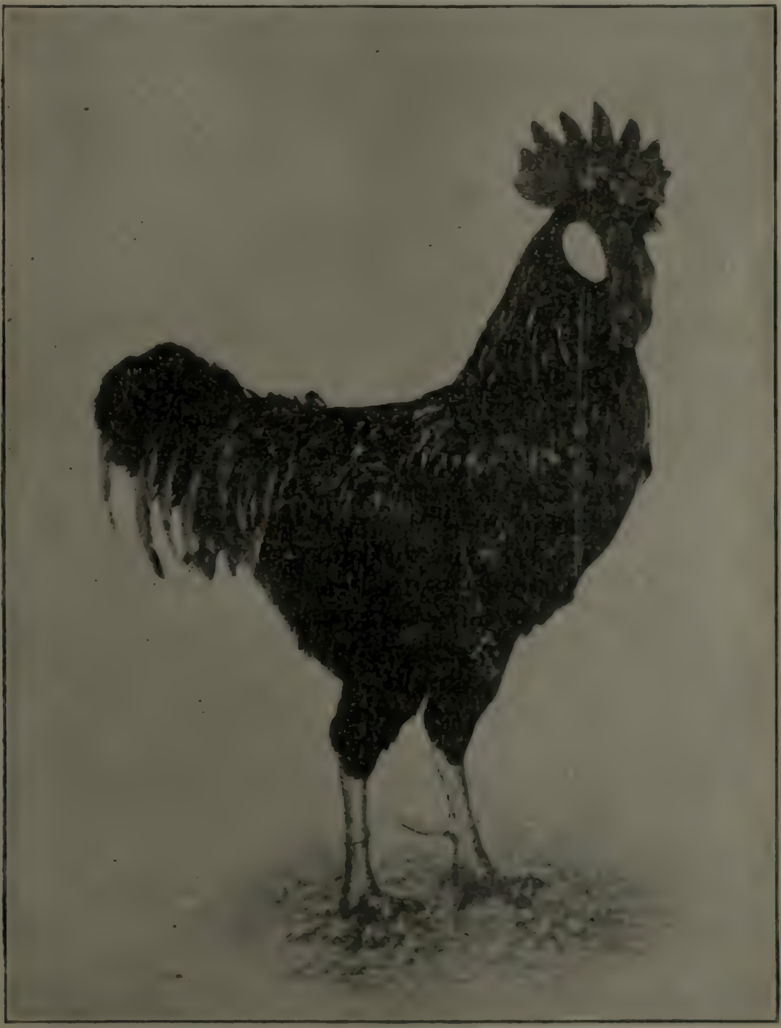

FIG. 11.—Single Comb Black Minorca, male.

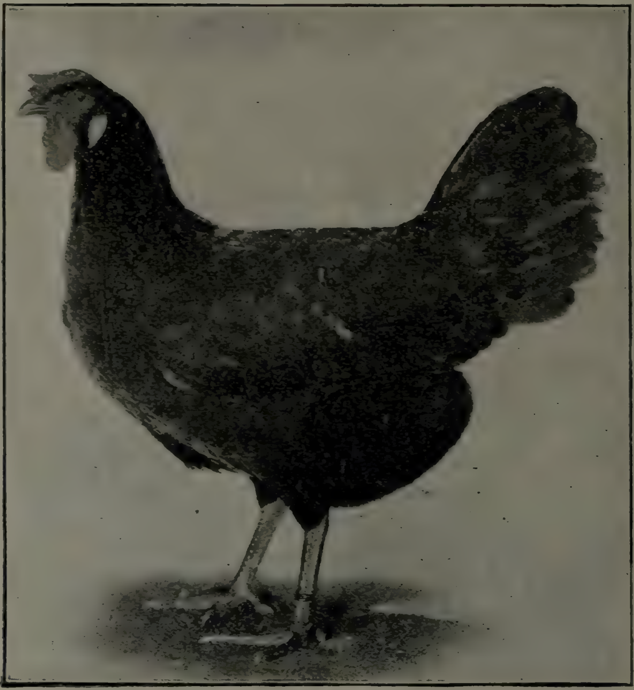

FIG. 12.—Single Comb Black Minorca, female.

The Minorca is the largest of the Mediterranean or egg breeds. It is characterized by its size, its length of body, and the large comb and long wattles. The Minorca shows a long back which has a noticeable slope from the shoulders downward to the base of the tail. The underline of the body is also noticeably long. The tail is rather low carried and is well spread. The Minorca also has long shanks and is well up on the legs, showing the hock and part of the thigh. The breast is prominent and well rounded. In general the Minorca is a more angular-looking bird than the Leghorn, as it does not have as smooth a curve where the back and tail sections join.

The comb of the single-comb varieties is unusually large. In the male it is erect and has six evenly and deeply serrated points. The blade of the comb has a tendency to follow the neck. In the female also the comb is large and six-pointed and is lopped. The front of the comb, instead of being straight as in the case of the comb of the Leghorn female, folds to one side, and then the remainder of the comb droops to the other side of the head. The comb of the male of the rose-comb varieties is fairly large, square in front, and terminating in a well-defined spike which has a tendency to follow the neck. The rose comb of the female is practically the same as that of the male in shape, but, of course, is smaller, although rather large for a female.

The skin of all varieties of Minorcas is white. This is a distinct drawback from the standpoint of the production of market poultry in this country, as the popular demand is for fowls with a yellow skin. The black and dark-slate legs and toes of the black varieties and the white or pinkish-white legs and toes of the white and buff varieties, are likewise a drawback from a market point of view, as the popular demand is for yellow-legged fowls.

The standard weights of the Single Comb Black Minorca are: Cock, 9 pounds; hen, 7½ pounds; cockerel, 7½ pounds; pullet, 6½ pounds. The standard weights of all of the other varieties of Minorcas are: Cock, 8 pounds; hen, 6½ pounds; cockerel, 6½ pounds; pullet, 5½ pounds.

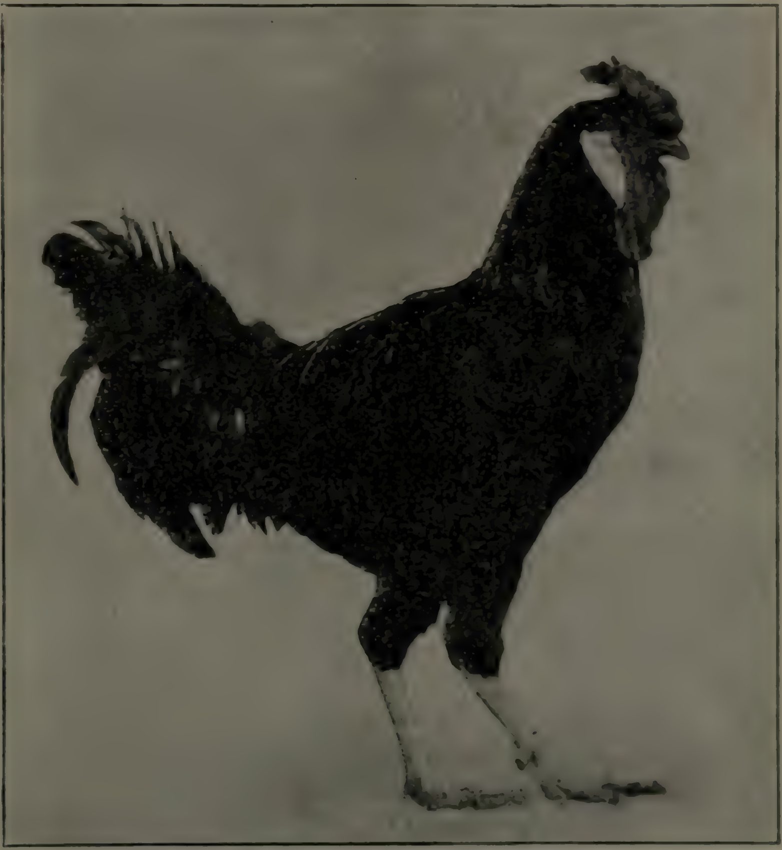

FIG. 13.—Rose Comb Black Minorca, male.

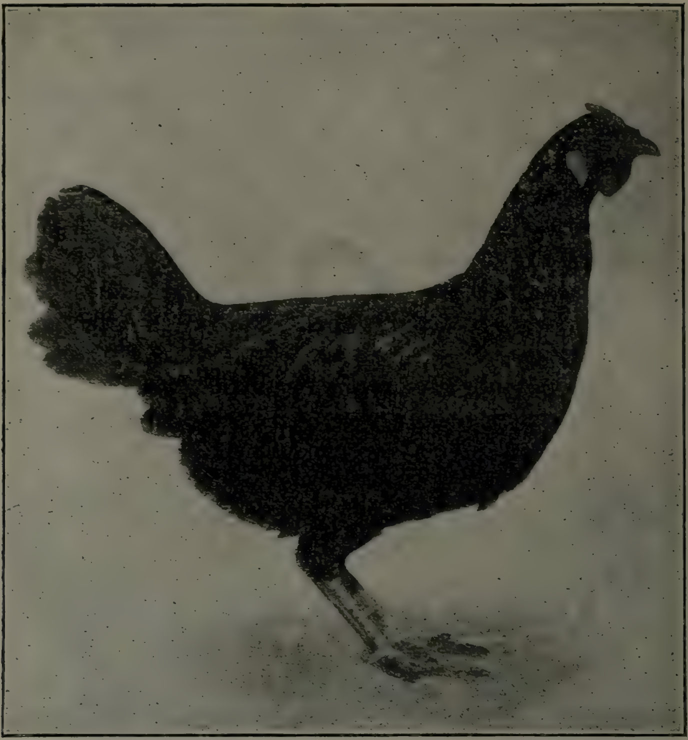

FIG. 14.—Rose Comb Black Minorca, female.

The Single Comb Black Minorca (figs. 11 and 12) undoubtedly is the best known of the Minorcas in this country. This variety is especially reputed for the size and pure white color of its eggs. The color of both sexes is black throughout, with lustrous greenish sheen over the surface, which should be free from purple barring. The undercolor of all sections is a dull black. The legs and toes are black or dark slate.

The Rose Comb Black Minorca (figs. 13 and 14) is identical with the Single Comb Black Minorca in shape and color, differing only in the matter of size and comb.

The Single Comb White Minorca is identical with the Single Comb Black Minorca except in the matter of size and color. Birds of both sexes are a pure white throughout, which should be free from any foreign color whatever. The legs and toes are a pinkish white.

The Rose Comb White Minorca is distinguished from the Single Comb White Minorca by the comb alone. In all other respects it is identical.

The Single Comb Buff Minorca is identical with the Single Comb White Minorca in type and size, being distinguished only by its color. This should be an even, rich, golden buff throughout, being identical with that of the Buff Leghorn. The legs and toes are white or pinkish white.

WHITE-FACED BLACK SPANISH.

The White-Faced Black Spanish (figs. 15 and 16) is generally considered to be the oldest fowl of the Mediterranean class. This breed undoubtedly was a native of Spain or one of the near-by countries. By reason of the very large, pendulous white face it is striking and unique in appearance. In type it is very much on the Minorca order, although it has not quite so long a body and has a somewhat higher carriage of tail. This breed is comparatively rare in the United States.

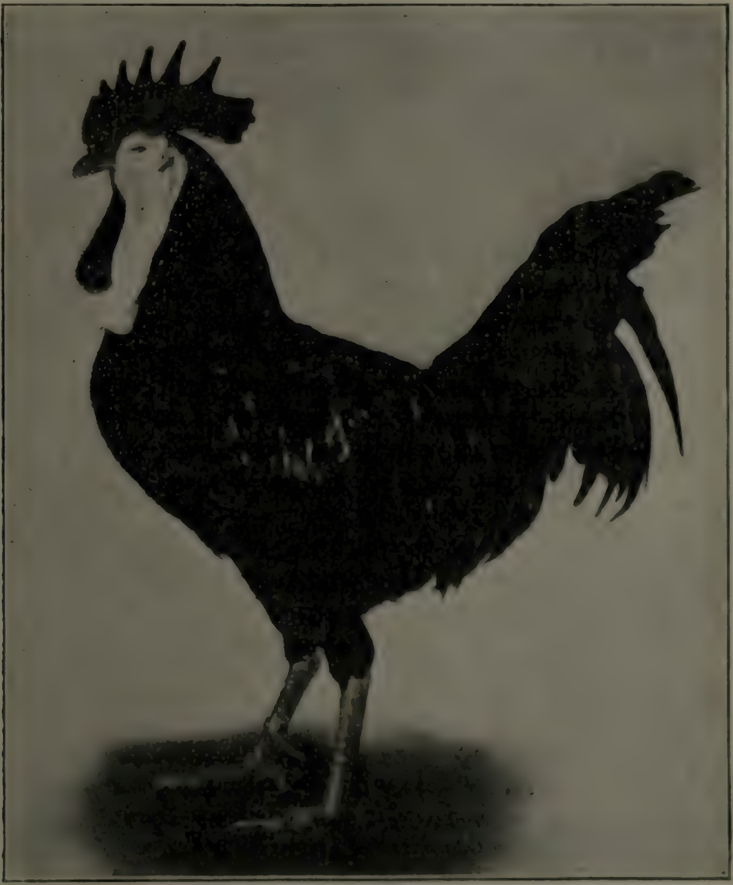

FIG. 15.—White-Faced Black Spanish, male.

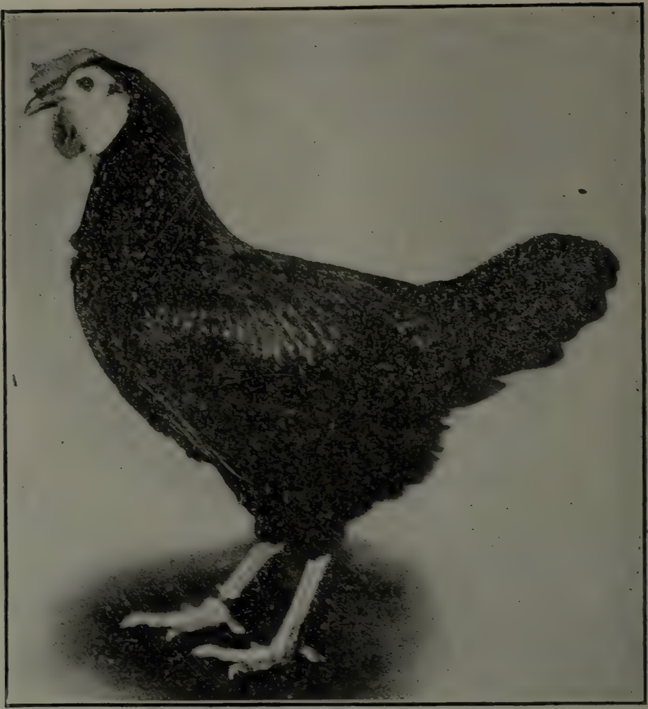

FIG. 16.—White-Faced Black Spanish, female.

The comb is single and rather large, although not so large as the Single Comb Minorca. It has five regular, deeply serrated points, and the blade extends nearly straight off the head, having little if any tendency to follow the neck. The comb of the female is erect in front and droops to one side, as in the Leghorn. The striking feature of this bird is a white face, which should be smooth and free from wrinkles, being long, deep, and pendulous. In breeding this fowl the white face is very important, the largest or longest and whitest face possible being desired. The face in males sometimes measures 7 inches in length. In color this bird has a black surface throughout with a lustrous greenish sheen. The undercolor is dark slate throughout. The color of legs and toes is a dark leaden blue or black. The color of the skin is white.

BLUE ANDALUSIAN.

The Andalusian (figs. 17 and 18) also is commonly supposed to be a native of Spain and has derived its name from the Province of Andalusia. Andalusians have been known in this country for a long period, but have never become very popular or very widely kept.

The Andalusian is very similar to the Leghorn in type, but is a slightly larger bird. The standard weights of the Blue Andalusian are: Cock, 6 pounds; hen, 5 pounds; cockerel, 5 pounds; pullet, 4 pounds.

This is a single-comb breed, and in the male the comb is somewhat larger than in the Leghorn and the blade has a slight tendency to follow the neck. The comb of the female is practically identical with that of the Leghorn female. The male has a general top color of dark lustrous blue, approaching black, which extends over the hackle, back, saddle, shoulders, sickle feathers, and tail coverts. The rest of the plumage is a slaty blue which shows in all sections a well-defined lacing of darker blue. In the female the general plumage color is a slaty blue of even shade, each feather except the primaries having a clear, well-defined, narrow lacing of darker blue. The neck has a decidedly darker cast of plumage than the rest of the body. The undercolor of both sexes is a slaty blue throughout. The legs and toes are leaden blue and the skin is white in color.

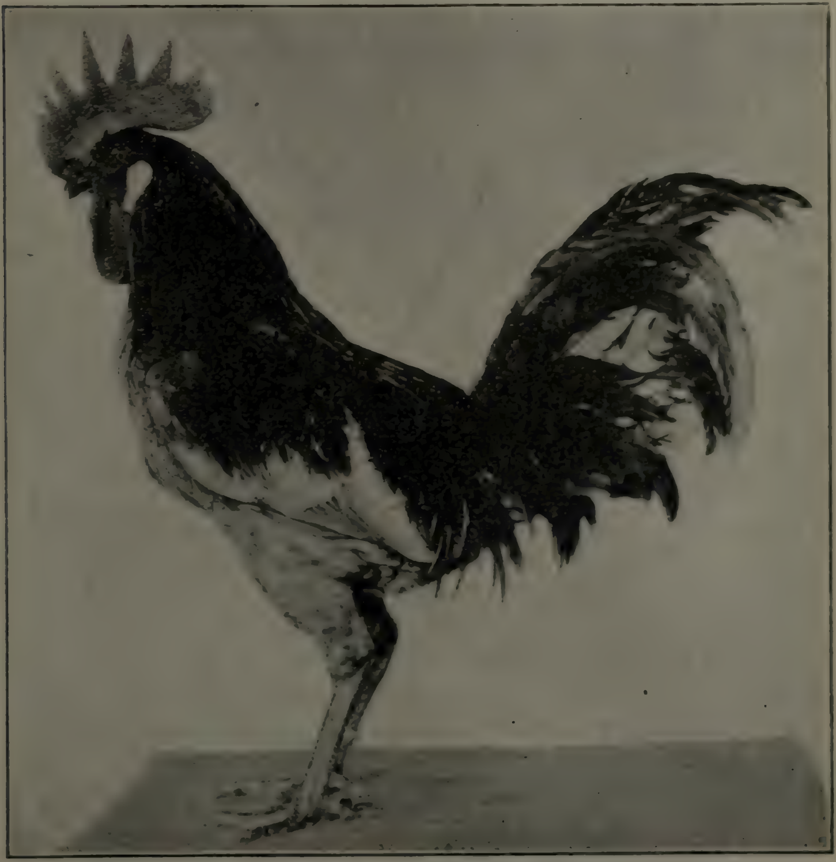

Fig. 17.—Blue Andalusian, male.

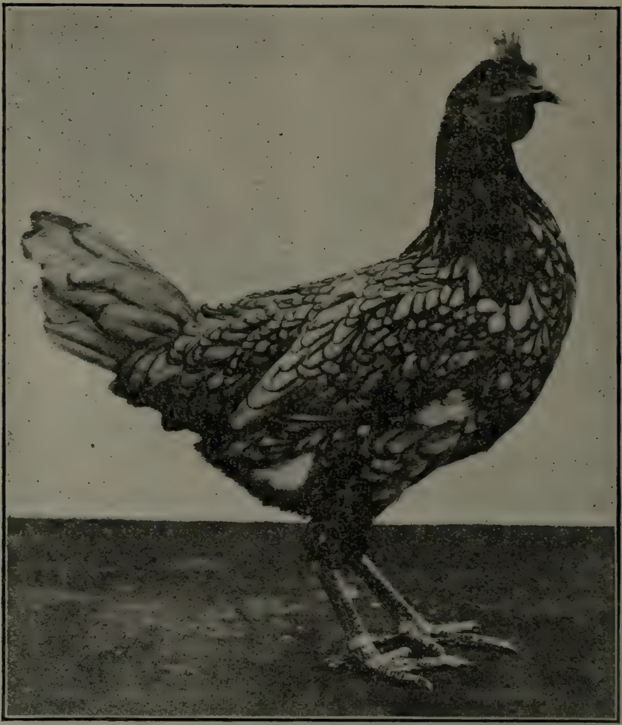

FIG. 18.—Blue Andalusian, female.

The behavior of the Blue Andalusian in breeding is peculiar and interesting. When both sexes in the mating are blue, the chicks hatched are never all of them blue, but approximately 50 per cent come black or white or some combination of black and white. One-half of this 50 per cent, or 25 per cent of all the chicks from the mating, are black or occasionally black showing some red, especially in the males, while the other 25 per cent of the chicks come some kind of white—in general, white splashed with black or blue. If matings are made in which one of the sexes is black and the other white, all of the chicks hatched will come blue. This latter form of mating is not generally used by breeders, however, for the reason that the quality of the blue produced in the chicks usually is not that desired. Breeders use only blue birds in their matings, selecting individuals which will give them the best color possible in the blue offspring and discarding the off-colored young birds for breeding purposes.

ANCONA.

The Ancona, like the Leghorn, is supposed to have originated in Italy. It is one of the older of the Mediterranean breeds, but has not been known in this country so long as the Leghorn or Minorca.

In type this breed is very similar to the Leghorn. In general it seems to have about the same utility qualities as the Leghorn, but has never gained the popularity which the Leghorn enjoys. In size the Ancona and the Leghorn are the same except that the standard weight for the Ancona hen is one-half pound greater. The standard weights are: Cock, 5½ pounds; hen, 4½ pounds; cockerel 4½ pounds; pullet, 3½ pounds.

The Ancona has a general body color of lustrous black with certain of the feathers throughout the plumage tipped with a V-shaped white tip. The proportion of feathers carrying such a white tip is one in five. The black top color of the male has a greenish sheen which is absent in the female. The main tail feathers and sickles of the male and the main tail feathers of the female are each tipped with white. The primary and secondary wing feathers also carry white

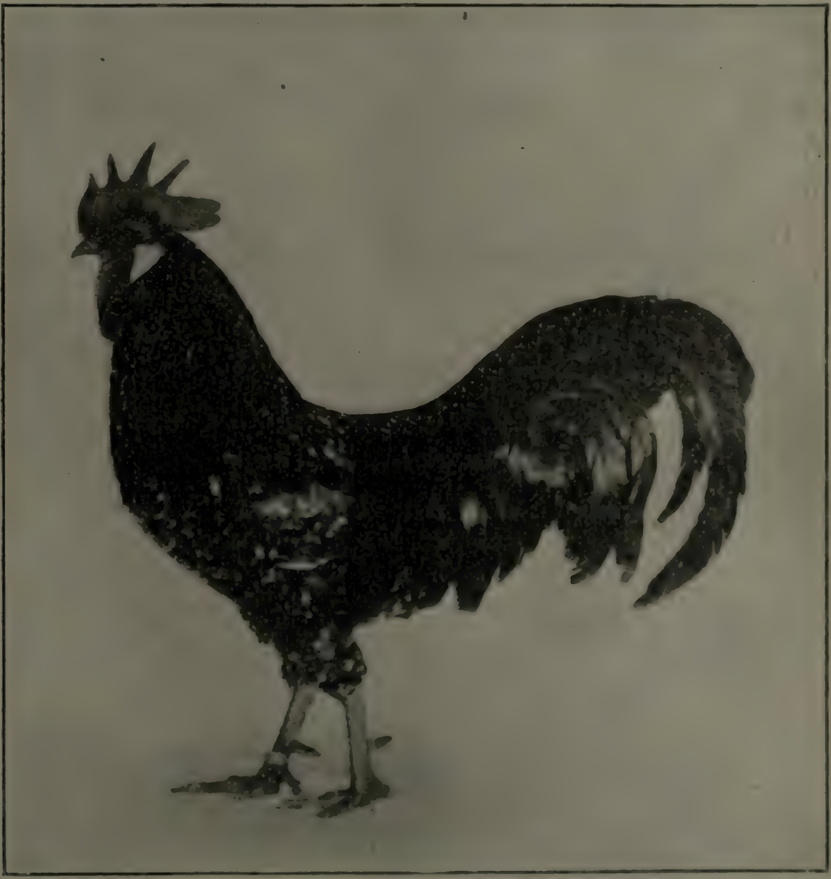

Fig. 19. -Single Comb Ancona, male.

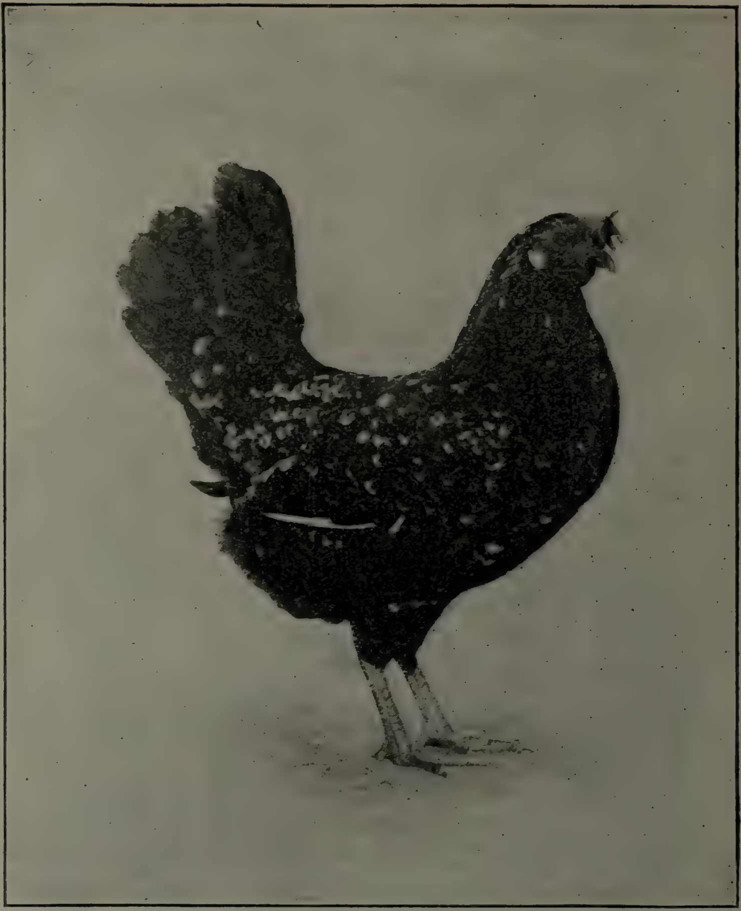

FIG. 20.—Single Comb Ancona, female.

tips. The undercolor is dark slate throughout. The legs and toes are yellow or yellow mottled with black, and the skin is yellow.

The Single Comb Ancona (figs. 19 and 20) and the Rose Comb Ancona are identical in every respect except in the matter of comb. The single comb of both sexes is identical with that of the Single Comb Leghorn, while the rose comb is identical with Leghorn Rose Comb in the female, but in the male is slightly smaller.

CAMPINE.

The Campine is a breed which originated in Belgium and has found a good deal of favor there as an egg breed. It is only recently that this breed has attracted attention in the United States, but it has gained favor rapidly and at the present time is enjoying a considerable measure of popularity.

In its general characteristics the Campine is very much like the Leghorn. It is a comparatively small breed, very alert and active, and of a nervous temperament. These fowls should be rather deep and long bodied and should be well rounded. The Campine female has, if anything, a longer back than the Leghorn female. Both varieties of Campines are single combed, the shape of the comb being the same as that of the Leghorn in both sexes. The standard weights are: Cock, 6 pounds; hen, 4 pounds; cockerel, 5 pounds; pullet, $3\frac{1}{2}$ pounds.

In the Silver Campine (figs. 21 and 22) both the male and the female have white heads and hackles. The rest of the plumage is a greenish black, each feather barred with distinct white bars, the black bars being wider than the white by about four times. The

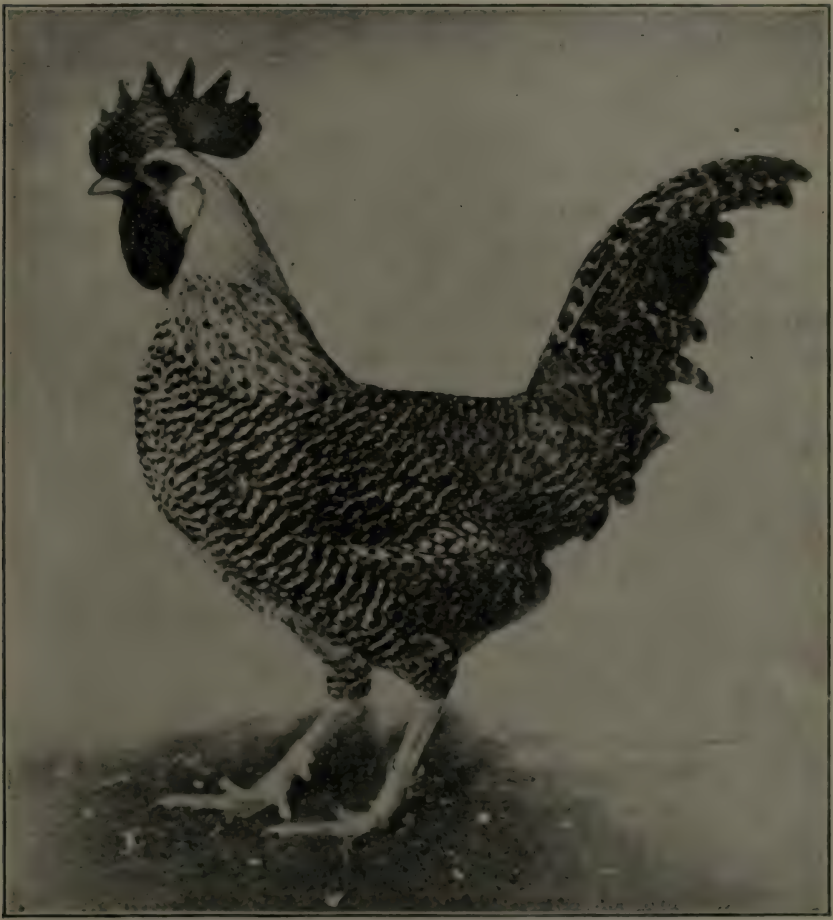

FIG. 21.—Silver Campine, male.

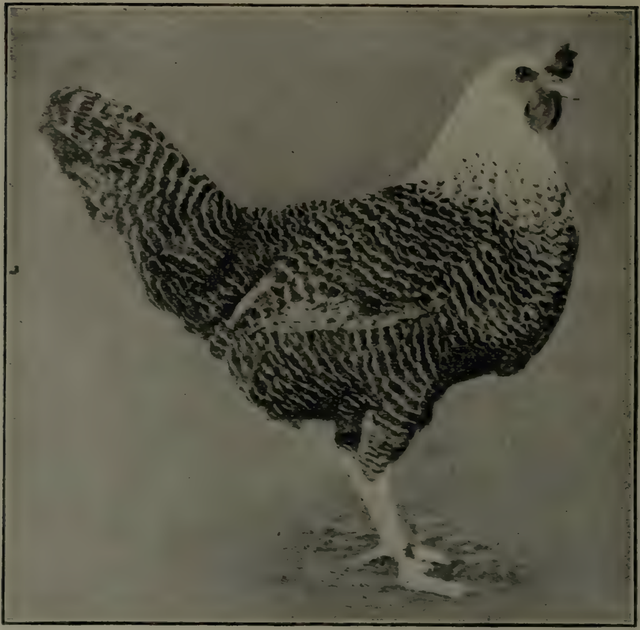

FIG. 22.—Silver Campine, female.

white bars do not extend straight across the feather, but have a slight tendency to be V-shaped at the quill. The undercolor is slate throughout. The legs and toes are leaden blue and the skin white in color.

The Golden Campine is identical with the Silver Campine except that the white of the Silver Campine is replaced by golden bay.

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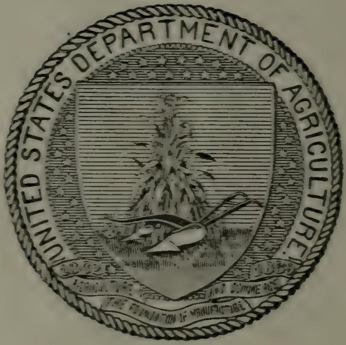
UNITED STATES DEPARTMENT OF AGRICULTURE

SURFACE IRRIGATION FOR EASTERN FARMS

F. W. STANLEY

Senior Irrigation Engineer

SUPERSEDED BY 1635

FARMERS' BULLETIN 899

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Office of Public Roads and Rural Engineering

LOGAN WALLER PAGE, Director

Washington, D. C. December, 1917

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IRRIGATION for the protection of valuable crops on eastern farms, which has been much encouraged in recent years, has been confined very largely to two methods, spray irrigation and subirrigation. Both systems are expensive, and subirrigation seldom is satisfactory except under peculiar soil conditions. This bulletin explains the methods of surface irrigation, which are simpler and less expensive than either the spray or the subirrigation method, and may be adapted to eastern farms.

The information should be helpful to farmers who have been discouraged from undertaking irrigation by the high cost of spray and subsurface methods, in spite of their belief that it would result in material increases in their crop yields.

SURFACE IRRIGATION FOR EASTERN FARMS.

CONTENTS.

	Page.
Conditions adapted to surface irrigation	4
Amount of water needed in furrow irrigation	5
Obtaining a water supply	7
Conveying the water to the land	9
Detail of pumping plants	11
Distributing the water	18
Applying the water to crops	27
Cost of irrigation	33
Information needed in design of a plant	35

THREE methods of irrigation are popular in sections of the Eastern States where conditions justify the artificial application of water to growing crops. These are known as the spray, the subirrigation, and the surface methods.

By the first method water is applied to crops in the form of a fine spray. It is adaptable to any topography or type of soil. The water is supplied under pressure, which is provided by an individual pumping plant unless city mains are tapped. The distribution system of the most common type of spray plant costs from $80 to $150 an acre. The main pipe line running from the water source to the field, together with the pumping plant or connection to a supply main, involves additional expense. The type of system just referred to for 5 to 10 acre units, pumping from wells or streams to adjacent lands, calls for initial expenditures ranging from $150 to $300 an acre, and sometimes more. Thus the crop which will justify irrigation by this method must be of sufficient value to warrant the financial outlay necessary for an irrigation plant and be increased in selling value by irrigation $50 or $60 per acre per year, which will pay interest at 6 per cent on the cost of pumping equipment and distribution system, 7 per cent depreciation of materials, and maintenance and operation expenses. All this indicates the necessity for highly intensive farming, sure markets, and ability to produce and handle a high-grade crop.

Underground irrigation is a method which the Department of Agriculture often is called upon to explain, but on account of the exacting conditions which must be present if this is to be success-

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NOTE.—Prices of pipe, pumps, and equipment given herein are those quoted early in the war, and are given merely as a guide. Prices since the beginning of the war have fluctuated so violently and suddenly that none can be quoted as standard.

ful, installations are not recommended often. The chief requisite for successful subirrigation is the combination of an open, porous surface soil, underlain with an impervious stratum which will tend to hold the water within reach of the plant roots. An ideal condition of this sort is the exception, which fact, together with the objectionable features of silt and roots, which tend to clog the tile through which the water is expected to enter the soil, high cost of installation and maintenance of the plant, and uncertainty as to results, does not recommend the adoption of the method, except after careful experimentation. Subirrigation ordinarily is extremely wasteful of water, and has had its greatest success in localities where flowing wells are obtainable. It is seldom to be recommended if the water supply must be pumped.

The high expense involved in both spray and subirrigation systems, and the more or less exacting conditions which must be met to permit the profitable operation of either, have discouraged many farmers from undertaking irrigation in spite of their desire for insurance against droughts and their belief that irrigation would result in material increases in their crop yields. This bulletin discusses the so-called surface methods of irrigation and their possibilities for the farmer whose pocketbook, crops, and market facilities do not justify consideration of the other methods.[1]

CONDITIONS ADAPTED TO SURFACE IRRIGATION.

Surface methods are of two types: furrow irrigation, and flooding. Both are used extensively in the arid sections of the United States, and their adaptation to Eastern conditions ordinarily is not difficult. Furrow irrigation, as its name implies, is merely the running of water down furrows between rows of plants, while irrigation by flooding is the spreading of water over fields, usually those in small grains, alfalfa, or grasses. The common field crops are not often irrigated in the East, yet in occasional instances cotton, corn, and potatoes have been irrigated with profit. Fruit trees respond to irrigation in many sections, the citrus groves of Florida being irrigated extensively.

Many farms are adapted to a combination of spray and furrow systems, the former to irrigate seed beds and small patches of garden truck, while the furrow system may be used for crops planted in rows. Where a combination of this sort is adopted the crops under spray usually are those on rolling or hilly lands whose contours do not permit easy irrigation by furrows. They generally are the quick-growing market-garden crops and berries, which require frequent watering. Such crops are irrigated best by the overhead spray system, since the application of water is effected more evenly and more easily by a spray system than by furrows. Many crops, nevertheless, are almost as well adapted to furrow irrigation, and where physical conditions are favorable the comparative cheapness of the furrow method recommends it above the more expensive spray.

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[1] Spray Irrigation, Bulletin No. 495, U. S. Dept. Agr., discusses in detail the various methods of irrigation by spraying now practiced in the Eastern and Southern States. A description of the subirrigation systems of Florida, where this method has had its most notable success, is contained in Irrigation in Florida, Bulletin No. 462, U. S. Dept. Agr.

Again, in most instances, where the furrow method is to be used, the crops are planted in rows far enough apart to permit cultivation with a horse-drawn implement. This obviously calls for a larger acreage than would be required for the same crop under spray, and market gardeners near large cities frequently find that the high value of their land justifies the more expensive method of irrigation, even though the topography would permit irrigation by furrows. It is a much more usual condition, however, where land values are not high, that farmers can afford better the extra acreage for furrow irrigation than the higher cost of spray equipment.

An accurate cost comparison between spray and furrow methods is hard to make unless actual cases are considered, but it is safe to assume that the cost of a pumping plant and main pipe line to the field for the furrow system will be slightly less than for the spray system, if the pumping lift is low. A lift of over 50 feet, if a spray system is used, calls for a pumping plant which often will cost two to ten times as much as a plant suitable for furrow irrigation. The field distribution equipment of a spray system will cost from three to twenty times as much as the distribution part of a furrow system.

It must be remembered, however, in comparing the advantages of the two methods, that the uniformity of distribution possible with a spray system can not be attained with furrows, and that the labor of watering a field by surface methods usually is much more than that necessary in the operation of a spray plant.

All flooding methods call for a nearly level ground surface, but most eastern soils will not permit much grading. It is not often that small grains, which ordinarily are irrigated by this method in the West, are irrigated in the East, although there is no reason why they should not be so watered if the fields are leveled properly and water can be supplied to them cheaply enough. Pasture is irrigated by flooding in parts of the North Atlantic States, but only in cases where direct diversion from streams is effected.

AMOUNT OF WATER NEEDED IN FURROW IRRIGATION.

Ordinarily irrigation in the humid sections is undertaken mainly for insurance against loss from drought. Therefore, the chief consideration is that the plants receive enough water to keep them in good condition until the next rain. It is not often practicable to irrigate crops by running water in furrows and apply less than 1 acre-inch per acre each irrigation. One acre-inch per acre is equivalent to 1 inch of rainfall, or 27,152 gallons. Measurement of water on heavy soils containing considerable clay shows that about this amount is required for an average irrigation; twice or three times as much may be required to irrigate sandy soils. In general, the limits may be placed between 25,000 and 60,000 gallons. In many instances the use of portable pipe, described later in this bulletin, will effect a considerable saving in water.

The acreage irrigated, then, will determine the total amount of water needed, and the time taken to apply this water will determine the quantity of water needed per unit of time. For instance, if a farmer wishes to irrigate 1 acre of stiff soil, and can irrigate 12 hours a day, he will probably need about 25,000 gallons, or about 2,000 gallons per hour, if he irrigates the whole piece in one day. If he is content to water one-fifth of an acre a day he will need only 400 gallons per hour, or 6.6 gallons per minute. If the water supply is limited, it may be necessary to extend the irrigation over a period of ten days or two weeks. Assuming the latter period, he will need 25,000÷14=1,786 gallons per day, or about 2.5 gallons per minute, irrigating 12 hours a day. If the soil is sandy and the grades are flat, he may need twice this amount. As a matter of fact, it is an exceptional case where so small a quantity of water can be used by surface methods unless storage is available, the foregoing computation being made merely to show the process of determining the water required.

For a larger acreage the same method of computation is followed. For instance, if 10 acres of tight soil is to be irrigated, multiply the above figures by 10, which will show that from 25 to 60 gallons per minute will be needed for 14 days of 12 hours each. In many cases it is necessary to figure on irrigating 24 hours a day in order to utilize a limited water supply, or to cut down the size of the pump. In such cases only one-half of the quantity per minute called for above would be required, but the total amount would be the same or probably more, as it is difficult to prevent a waste of water when irrigation is undertaken at night.

Where the water is taken from streams and can be carried to the land by gravity, the quantity is not of so much importance as when it must be pumped, since in the latter case the supply is apt to be limited and the cost of pumping comparatively heavy. In many instances large acreages can be irrigated very cheaply where gravity supplies are easily accessible, but favorable conditions of this sort are seldom found in the East.

OBTAINING A WATER SUPPLY.

The item to be considered first in planning a furrow-irrigation plant is the water supply. This must be near enough to the land to justify the cost of putting in the pipe line or ditch to carry the water. In most cases in the East it is not practicable to divert water directly to the land from a stream, as is done frequently in the West, because such a diversion must be made at a point high enough upstream to permit the water to flow down the ditch to the land to be irrigated. In many instances this would require a ditch of considerable length, even when the irrigated farm is not large; and where the land which must be crossed by the ditch is of much value or belongs to other farmers the obstacles in the way of constructing a gravity system are serious. Therefore a pumping plant is a common adjunct to the irrigation system, whether the source of supply be a well, stream, or lake. Usually it does not pay to pump water through a vertical lift of more than 100 feet for the ordinary field crops, although valuable truck crops may justify a lift of over 200 feet. If the water is near the land to be irrigated, the main pipe or ditch need not be very expensive. A long pipe line is costly, however, and the economical limit of length is soon reached for most field crops.

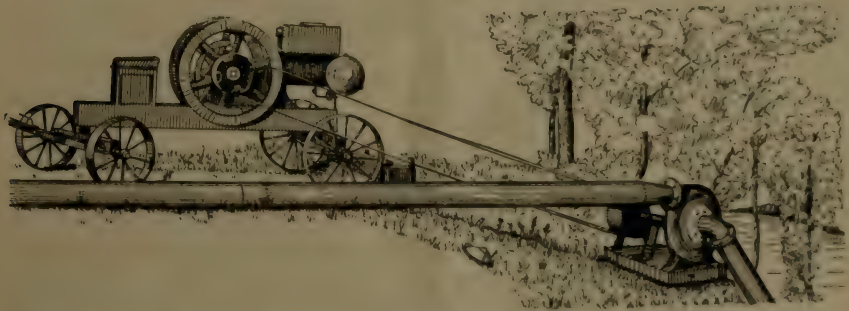

FIG. 1.—Horizontal centrifugal pump operated by portable gasoline engine.

If water is pumped from streams or lakes the installing of pumping machinery is simple, unless there is danger of floods or the banks are unusually steep. The pump, unless it be of the plunger type discussed on page 13, must always be placed within suction lift of the water supply, which for practical purposes is under 25 feet. Where there is danger of floods, it is best to place pump and engine on skids or wheels so that they can be moved quickly and easily. (See fig. 1.)

If the water supply of the stream is not sufficient, conditions may permit the making of a small storage reservoir [1] by building a dam at some suitable point. Small quantities of water pumped by rams or windmills may be used to water small patches when used in conjunction with reservoirs.[2] Springs sometimes yield enough water for irrigation, and when favorably located may permit the water to be conveyed to the land by gravity. Usually such sources yield small quantities of water and will serve only small areas.

If a stream falls fairly rapidly and carries an abundant supply of water, its own power may be used to lift a supply to the land. A hydraulic ram or water wheel and pump is used in such a situation. Such devices have the advantage of low operating cost, and often may serve other purposes beside pumping. Many water wheels, for example, used for milling or cotton ginning, could be made to operate pumping machinery also. Water-power devices for pumping purposes only are often a great deal more expensive than power pumps, however, and in many cases are subject to washout during high water. Moreover, many hydraulic rams now in use do not deliver enough water for irrigation purposes. The large sizes chiefly used for irrigation are expensive, and are more adaptable to western conditions than to those where irrigation water is needed only a small portion of the time.

Wells are a common source of supply for irrigation purposes. Several types are used: The dug or open well is of much use in some sections, but for the most part the amount of water made available by it is too small for any but domestic use. Dug wells are affected considerably by droughts, and often are dry or nearly so when water is needed most.

Drilled or bored wells often yield large amounts of water. Some wells of this type flow and provide sufficient water to irrigate several hundred acres. Most drilled wells do not flow, however, although many of them will yield liberally when pumped. It is a comparatively easy matter to pump from bored wells when the water stands within 25 feet of the surface, but to obtain large irrigating heads when the water is 30 feet or more below the surface would require expensive pumping equipment. Small quantities, however, can be pumped from such wells at a moderate cost.

Driven wells also are used for irrigation purposes, and are a cheap source of water where the lift is less than 25 feet. One 2-inch well

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[1] Various types of small reservoirs which should be of interest to readers of this bulletin are discussed in Bulletin No. 179, Office of Experiment Stations, part 1 of Bulletin No. 249, Office of Experiment Stations, and Farmers' Bulletin No. 828. The department's suppy of Bulletin 179 and part 1 of Bulletin 249 has been exhausted, but copies can be obtained from the Superintendent of Documents, Washington, D. C, for 20 cents and 30 cents, respectively. Farmers' Bulletin No. 828 is available for free distribution by the department.

[2] See Farmers' Bulletin No. 866.

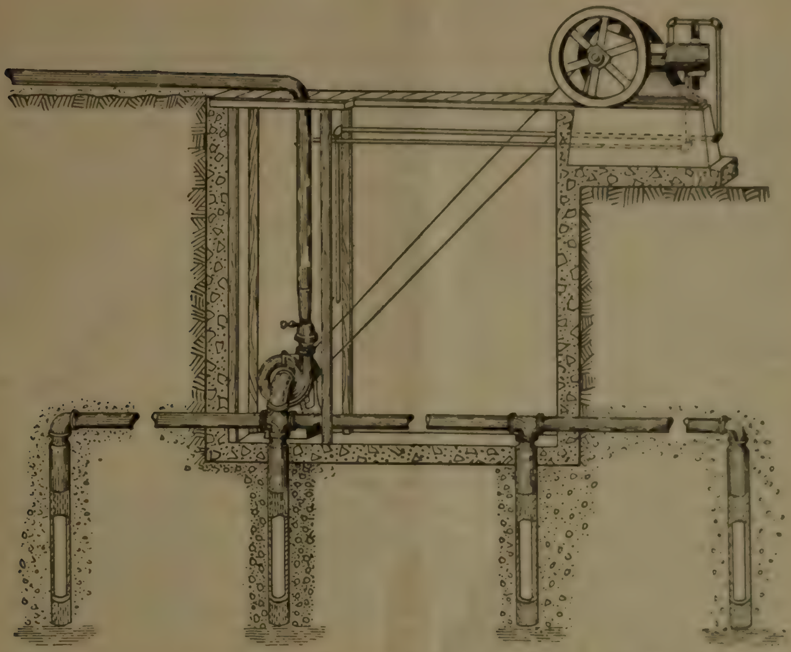

FIG. 2.—Horizontal centrifugal pump set in concrete pit, to pump from several connected wells. Pit is required because the suction lift from the gravel surface is more than 25 feet.

usually will yield from 10 to 40 gallons per minute, if the point is driven in a good sand or gravel water-bearing stratum. A large number of points may be driven and connected to one central pump. Where this is done it is common to place the well points from 25 to 50 feet apart. If the water-bearing stratum is more than 25 feet below the surface, the same method often can be followed by digging trenches, laying the connecting pipes in them, and setting the pump in a central pit. The pit and the connecting trenches must be deep enough to reduce the vertical suction distance to 25 feet or less. (Fig. 2.)

CONVEYING THE WATER TO THE LAND.

The conveyance of water from the source of supply to the land usually is one of the most difficult problems that face the irrigator. If the supply source is wells, either flowing or pumped, located at the highest part of the farm, the water can be carried to the furrows by open ditches at very little cost. Often water will rise as high in a well at the higher elevations of the farm as at the lower, but if a pumped well at a lower elevation within suction lift would yield sufficient water, while a well on the higher elevation would require a deep-pump pit, it might be cheaper to drill the well at the lower point and force the water to the higher elevations through a pipe line.

If water is to be diverted from a stream by means of an open ditch, the proper size of the ditch and its grade or fall in inches per 100 feet of length must be determined before excavation is commenced. The size of the ditch will depend for the most part on the acreage to be watered. Usually the grade is kept as flat as is practicable, so as to retain a good elevation at the point of delivery. If the diversion point from the stream is high, the grade of the ditch must be determined by the character of the soil, for if the grade is made very steep in order to cut down the size of the ditch trouble from washouts is likely to result, especially if the soil is sandy or if the ditch has been carried along a hillside or across earth fills.

A small ditch can be carried on a steeper grade than a large one, owing to greater friction. Several influences enter into the exact determination of the friction factors in mathematical formulas used by engineers in designing open ditches, but, generally speaking, wide, shallow ditches, with rough and irregular sides and bottom, crooked and subject to many changes of grade, will not carry nearly as much water as straight, deep ditches of regular outline. Table 1 shows common shapes and sizes of farm ditches with permissible grades to carry given amounts of water.

TABLE 1.—*Discharges of ditches with different grades.*

Dimensions of ditch.				Grade in inches per 100 feet.	Discharge.
Top width.	Bottom width.	Depth.	Area of cross-section.		
Feet.	*Feet.*	*Feet.*	*Sq. feet.*		*Galls. per min.*
1.5	1	0.5	0.6	2.00	300
3.0	2	1.0	2.5	.50	800
4.5	3	1.5	5.6	.25	1,600
6.0	4	2.0	10.0	.20	3,500
11.0	8	3.0	28.5	.12	9,000

This table shows sizes and grades for ditches designed to carry water at a safe velocity for average soils. The shapes are for practical ditches and can be followed safely for ordinary heads. It should be noted how rapidly the grades diminish as the quantity of water to be carried increases. The velocities are nearly the same in all the ditches, a slightly greater velocity being allowed for the small ditches than for the larger ones. If the grades are taken appreciably flatter than those given above for similar amounts of water, the water is apt to run too sluggishly, so that weeds and silt soon will tend to clog the ditch.

In such a situation as that just outlined the expense of irrigation should be small, unless a substantial diversion dam or a long main ditch is required. On the other hand, if the distance from the source to the land is considerable, a pipe line also would be too expensive, and a cheaper plan would be to install a pumping outfit on the bank of the stream, the pump being set as near as possible to the land to be irrigated.

DETAIL OF PUMPING PLANT.

Where water is pumped from streams or other open bodies of water, a centrifugal pump usually is the cheapest and best type for surface irrigation. The advantages of a centrifugal pump are its low cost, light weight, lack of valves and parts that wear out easily, comparative ease of operation and maintenance, and relatively high efficiency in raising large quantities of water through moderate lifts.

The single-stage horizontal is the type of centrifugal pump in most common use for irrigation, being especially adapted to pumping quantities of water above 250 gallons per minute from streams or from wells where the suction lift is not over 25 feet. If the water from a well must be lifted from 25 to 40 feet, this pump usually can be set in a pit and belt-connected to an engine at the ground surface. If electric power is available, it often is possible to dig a pit and set the pump directly con-

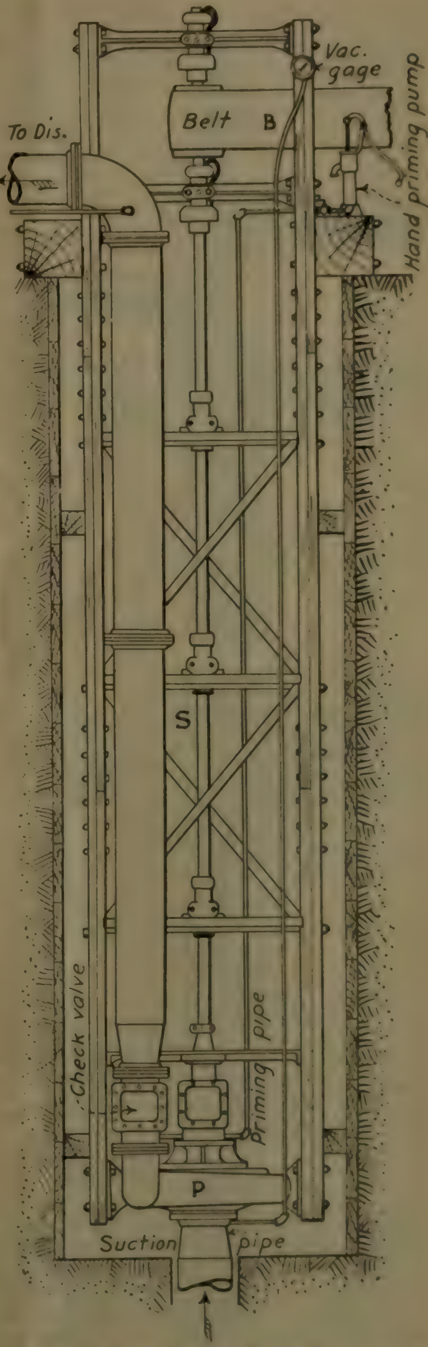

Fig. 3.—Vertical centrifugal pump in pit. Pump P is operated through vertical shaft S by means of half-turned belt B.

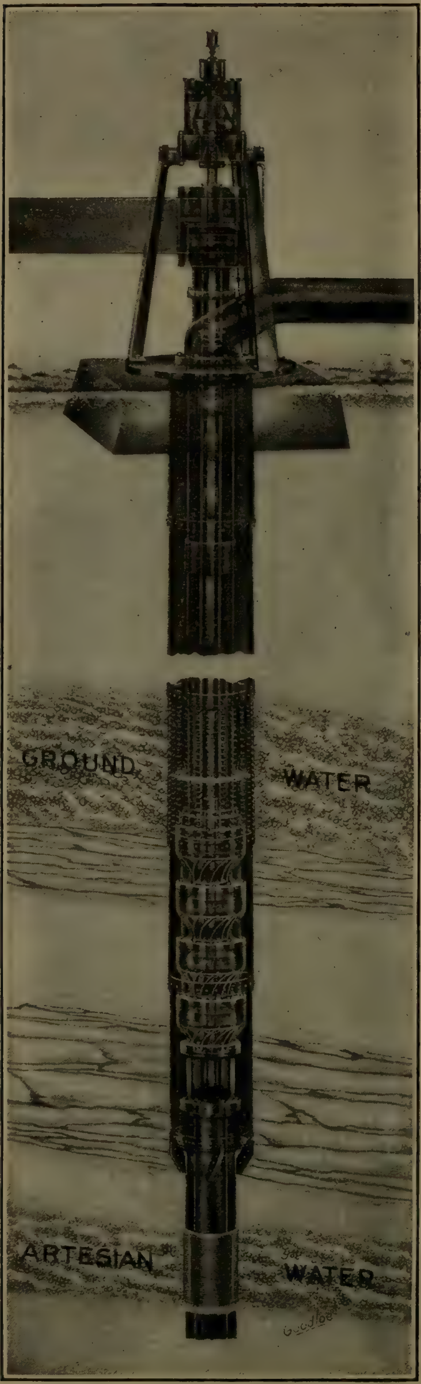

FIG. 4.—Deep-well turbine pump, operated by half-turn belt.

nected to the motor at the bottom. Horizontal centrifugal pumps are made in several stages, depending on the lift. The ordinary single stage pumps are made to pump water through total lifts up to 125 feet. Pumps of more than one stage will lift water to considerable heights, but they are much more expensive than those already referred to.

Another type of centrifugal pump used for irrigation purposes is the vertical centrifugal (fig. 3). This differs from the horizontal type in that the impellers are operated by a vertical shaft, which may be of considerable length. This type is used almost exclusively for pumping from wells where the water table is below the permissible suction lift, as the pump may be set in a deep pit below the groundwater level and operated by a belt-driven pulley on top of the vertical pump shaft. Vertical centrifugal pumps cost about 50 per cent more than horizontal pumps of the same capacity. To the cost of the pump itself must be added the cost of pump pit and framework which contains the vertical shaft. The vertical type usually requires about 10 per cent more power than the horizontal.

Several types of centrifugal pumps are constructed for pumping water from deep wells, where the suction lift is too great to allow the utilization of pits dug by hand. These usually are called deep-well turbine pumps (fig. 4). They are similar in general principles to the vertical centrifugal type, with impellers incased in a shell, but are so constructed that they can be let down to any required depth in drilled wells of large bore. Wells 12 inches and more in diameter may be pumped by this type. If a deep well of less than 12 to 15 inches diameter is to be drilled, it is common to bore a larger well to the water level. This will contain the pump. The well of smaller bore then is started and may be bored to a great depth. Deep-well pumps of large capacity are expensive, costing from 5 to 10 times as much as horizontal centrifugal pumps. To the cost of a pump of this type must be added the extra cost of boring and casing the larger well containing the pump. Deep-well pumps are efficient when delivering quantities of 500 gallons per minute or more and are moderately free from trouble if properly installed.

Water often may be raised successfully from deep wells with high lifts by means of the so-called air lift. This apparatus includes an air compressor which forces air into the water near the bottom of the well. Released there the air seeks to rise to the surface, and in doing so forces a quantity of water from the well. One compressor may supply air for several wells, as the air may be piped a considerable distance from a central power house. The advantages of the air lift are the absence of complicated apparatus beneath the ground surface, and the ease with which a large number of wells may be pumped from one central station. This type is adapted especially to deep-well pumping where the water supply is uncertain. However, this pump usually is less efficient than the centrifugal type under moderate lifts, and is more costly. It usually is more efficient if operated by steam than by gas engine.

The ordinary plunger pump commonly used on the farm to raise water for domestic purposes may be utilized in irrigating small areas. This pump is adaptable to nearly all conditions, and is especialy useful for pumping water from wells where the lifts are high. Plunger pumps are made in many types to pump widely varying quantities of water, these falling, however, into three main groups—with single cylinders (simplex), two cylinders (duplex), or three cylinders (triplex). Each of these forms may be either single or double acting. For quantities of water up to 100 gallons per minute, the single-cylinder or duplex pumps are satisfactory and more efficient than centrifugal pumps. For quantities from 100 to 200 gallons per minute the plunger types are rather expensive, when compared with the centrifugal, but their higher efficiencies often recommend their use in spite of this fact. Where more than 250 gallons per minute is to be pumped, it usually is best to install a centrifugal pump, as the cost is very much lower than that of the duplex pump. A triplex pump practically never should be used for surface irrigation unless the lift is great or the pump is to be used for other purposes in addition to irrigation.

Plunger pumps are recommended where water is pumped from a battery of driven wells if a shortage of water is likely to occur, as they are self-priming. The centrifugal pump must be primed, unless submerged, and the suction pipe must be airtight.

Since centrifugal pumps are designed for known constant lifts and run most efficiently against those lifts, pump companies from whom cost estimates are desired should be informed regarding the lift and other conditions, and the specifications finally accepted should be adhered to closely in installing the pump. Plunger pumps may be operated under varying speeds and heads, but as in the case of the centrifugal type, the maximum efficiency will be obtained under the conditions for which the pump is designed.

Nearly all centrifugal pumps are fitted with pulleys and are belt-connected to gasoline engines, electric motors, or other sources of power. Direct connection is advisable, however, wherever practicable, since by it loss of efficiency by belt slippage is eliminated and the outfit is made much more compact. The power will, of course, depend upon local conditions.

The most common power source is some form of internal-combustion engine (figs. 5 and 6). Many engines still use gasoline for fuel, but nearly all of the new farm engines are fitted to burn kerosene, and some burn the heavier oils very successfully. Small engines generally are best fitted to burn kerosene. For an engine of 20 horsepower or more it sometimes is advisable to fit the engine with a gas-producer apparatus, so that the heavy fuel oils may be used; but it must be remembered that an engine used for irrigation purposes only will be operated for short periods in most parts of the

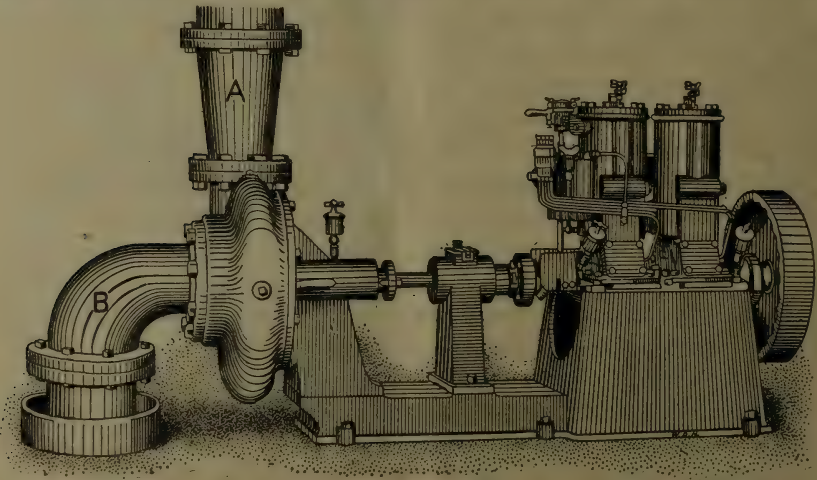

Fig. 5.—Horizontal centrifugal pump direct-connected to 2-cylinder marine engine. A shows discharge and B suction pipe. Note taper of both.

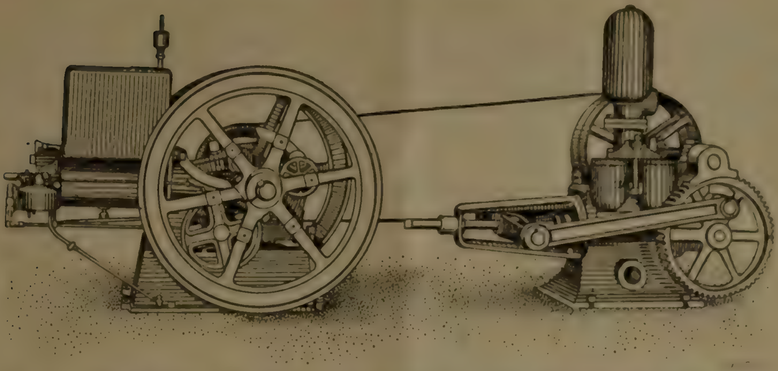

FIG. 6.—Gasoline engine belt-connected to single cylinder, double-acting power pump.

humid sections. A possible saving in expense for fuel therefore is likely to be unimportant, inasmuch as the expenses incurred in installing a heavy-oil engine may far offset it.

The cost of gas engines varies widely. Those adapted to small irrigation systems, with from 1 to 5 horsepower, should cost from \$25 to \$40 per horsepower; 5 to 25 horsepower engines should cost from \$15 to \$50 per horsepower. The cheaper grades are recommended for most plants used for furrow irrigation in the Eastern States, on account of the short periods during which they are operated.

As in the case of the pump, the engine used in connection with an irrigation plant in the Eastern States often may serve other purposes, especially if it is portable. If the engine is already serving other purposes when the pumping plant is installed, the pump must be adapted to the engine, instead of the reverse, as is usual.

Steam engines usually are economical where wood fuel is plentiful, as is the case in many sections of the South where pine is abundant. However, for the plant of less than 25 horsepower it seldom is economical to purchase a new steam-pumping outfit, as the initial cost of steam engines is considerably more than that of gas engines, and they require more labor for attendance. If electric current is available at moderate rates motors will prove very satisfactory, operating with a minimum of trouble. If a flat rate is charged for power, however, the operating charges may be prohibitive.

The size of the pump will depend on the time allowable for the irrigation of the area to be watered. The horsepower required to operate the pump depends on the quantity of water to be lifted, the elevation of the land above the water source, and the distance the water must be carried in a pipe.

The following table shows the amounts of water needed to irrigate different acreages in reasonable time. If the amount of water which is needed is known the size of the pump and the power needed to operate it may then be ascertained. The total horsepower required will be found by multiplying the number found in the table by the total lift. The total lift will be the actual lift from the water surface to the highest part of the farm plus the loss due to friction. The friction loss, shown by column 7 of the table, depends upon the size and length of the pipe. This is shown in feet per 100 feet of main pipe line. Data in Table 2 apply to favorable conditions of soil and grade where the suction lift is 25 feet or less and where the total lift is not more than 100 feet.

TABLE 2.—*Sizes of pumps and engines required for the irrigation of different areas.*

Area.	Water required per 2-inch irrigation.	Capacity of pump per minute.	Size of pump.[1]	Kind of pump.	Size of discharge pipe.	Friction loss in discharge pipe per 100 feet.	Efficiency of pump.	Horsepower of engine per foot of lift.	Approximate cost of pump.
Acres.	*Gallons.*	*Gallons.*	*In. or No.*		*In.*	*Feet.*	*Per ct.*		*Dols.*
¼	13,500	10	3 by 5	Double-acting plunger.	1½	1.1	30	0.01	40
½	27.000	10	3 by 5	do	1½	1.1	30	.01	40
1	54.000	20	4 by 5	do	2	1.0	30	.015	50
2	108.000	35	5 by 5	do	2½	.9	30	.025	60
3	160.000	35	5 by 5	do	2½	.9	30	.025	60
4	210 000	55	6 by 6	do	3	1.0	40	.035	75
5	270 000	110	6 by 12 or No. 2	do Centrifugal	4	1.0	40	.070	100 45
10	540 000	225–265	3	do	5	1.2–1.7	40	0.14–0.17	60
15	800 000	300–370	3½	do	6	.9–1.4	40	.19– .23	65
20	1 000 000	400–500	4	do	6	1.5–2.2	45	.20– .28	75
25	1 300 000	700–750	5	do	8	1.0–1.2	50	.35– .37	85
30	1.500 000	700–750	5	do	8	1.0–1.2	50	.35– .37	85
40	2.000 000	900–1.100	6	do	10	.6– .9	50	.45– .55	115
50	2.700 000	900–1.100	6	do	10	.6– .9	50	.45– .55	115
75	4.000.000	900–1.100	6	do	10	.6– .9	50	.45– .55	115
100	5.400 000	1.200–1.500	7	do	12	.4– .8	55	.55– .68	140
200	10 800.000	1,600–2,200	8	do	12	.8–1.4	55	.73–1.0	170

[1] Double-acting plunger pumps are sold by diameter of the plunger, in inches, and the length of stroke, in inches, which are the dimensions shown here. Centrifugal pumps are sold by number, which describes the diameter of the discharge pipe, in inches, at the pump.

To illustrate the use of Table 2, assume that it is desired to irrigate 10 acres, that the highest point of the land is 40 feet above the water supply, and that the pipe line from the pump to the land is 1,200 feet long; then from the table see that a No. 3 centrifugal pump will be needed to supply this. To determine the horsepower needed to operate the pump determine first the total lift, which will amount to the difference in elevations, 40 feet, plus the friction loss. If 5-inch pipe is used, the friction loss in it will be equivalent to 1.5 foot of lift for each 100 feet of pipe. There being 1,200 feet of pipe, the friction loss will be 12×1.5=18 feet; so that the total lift to be considered will be 40+18=58 feet. The total horsepower called for will then be 58×0.16=9.3, this being at the rate of 0.16 horsepower for each foot of lift. A 10-horsepower engine would be recommended for this plant.

In many cases it would be possible to use smaller discharge pipe than the sizes recommended in Table 2, but if that were done higher power would be required to force the water through it. Where conditions require the use of smaller pipe the matter of specifications would better be referred to the pump or engine manufacturers, to the Department of Agriculture, the agricultural experiment station of the State in which the farmer lives, or to a local engineer. The table can not be made to apply to all possible conditions, of course, but should give a basis for computing the probable cost of an irrigation plant.

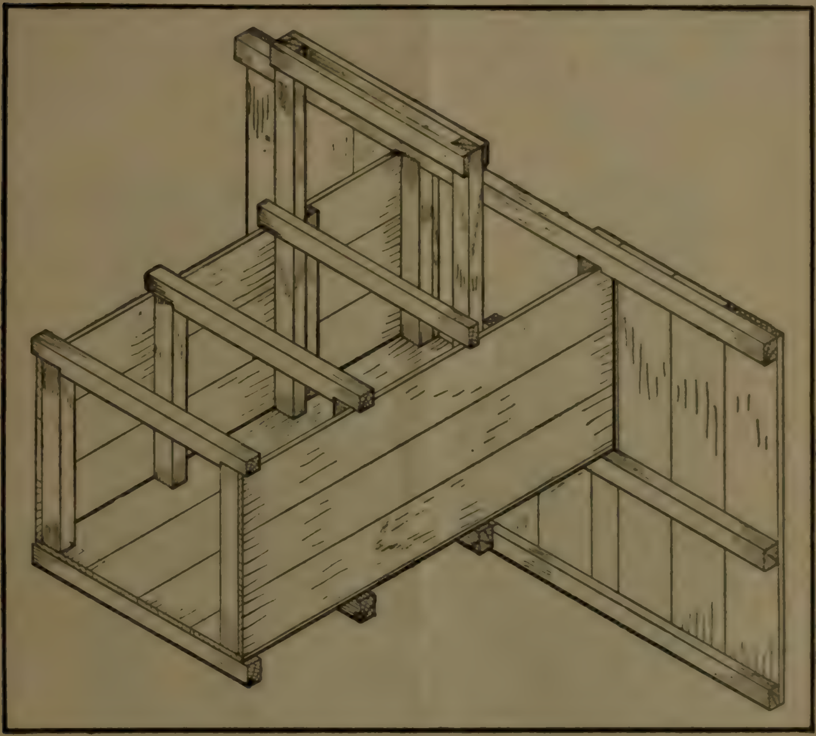

FIG. 7.—Small wooden headgate.

Details of the installation of pumps and engines can not be entered into here. Generally speaking, suction and discharge pipe should be large enough to reduce friction loss to a minimum and all unnecessary sharp bends should be eliminated. Where possible to do so, it always is best to consult a pump expert before installing a plant. Companies manufacturing pumps usually are prepared to give advice on such details, and in many cases will oversee the installation.

DISTRIBUTING THE WATER.

The control of water from the larger ditches requires the installation of various structures. Wood ordinarily is used at first, but concrete should be used if the structures are to be permanent. It often happens that wooden structures can be used until the system has been tested thoroughly. The lumber in these may be used for forms when the time comes to install more permanent concrete works. Wooden boxes usually are put in when a small ditch is taken from a main. (Fig. 7.) Such a structure is made in form of a rectangular box open at the top, and may have one, two, or three outlets. The water is controlled best by means of movable boards or slats fitted to slots made by cleats nailed to the side of the box.

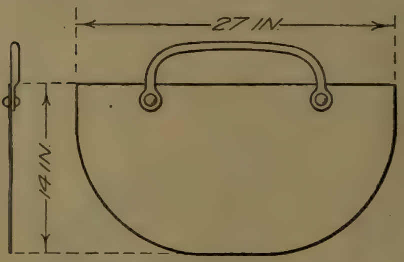

FIG. 8.—Metal dam, or tapoon.

Small ditches, however, generally call for structures only at the intake. Elsewhere the water may be controlled either by filling the ditch with dirt at appropriate places and cutting the bank with a shovel, or by the use of portable canvas or sheet-iron dams (fig. 8). In using the canvas dam the irrigator places the top slat across the ditch and throws a little dirt on the canvas at the bottom and sides. The portable sheet-iron dam is used by merely thrusting it into the ditch at right angles to the flow and deep enough to stand the pressure of the water against it.

Water is taken in a number of ways from the small ditches at the head of the furrows. The common way is to cut small trenches through the side of the ditch with hoe or shovel. A better method calls for the use of lath spouts or pieces of pipe set through the banks of the ditch (fig. 9). The amount of water let into the furrow may be regulated either by a cloth flap at the intake of the lath spout or by a shingle thrust into the earth in front of the tile.

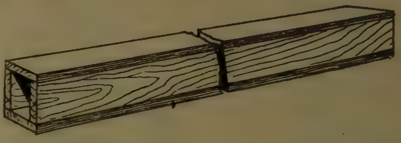

FIG. 9.—Lath pipe for ditch bank.

TERRA-COTTA PIPE SYSTEMS.

A durable and comparatively cheap distribution system may be constructed of terra-cotta sewer pipe, usually called salt glazed vitrified clay pipe. This pipe can be made watertight under low pressure and can be laid by anyone who follows directions carefully. A distribution system of this pipe should not be designed to stand a vertical head of more than 10 to 15 feet or a pressure of more than 4 to 6 pounds per square inch. Therefore, if it is necessary to cross a dip or hollow it is best to cross it with iron, steel, or reinforced-concrete pipe. As is done with open ditches, pipe lines are laid along the highest side of the land to be irrigated, and the water is let into the furrows at convenient points. It often is possible to lay the pipe on top of a ridge across a field and run the water down both slopes.

None but the best grades should be accepted when the sewer pipe is bought. Pipe with cracks or broken ends should be rejected. The best way to test for cracks is to tap the pipe lightly with a hammer, a clear ring usually indicating a sound pipe. Pipe which is not well formed also should be discarded; no serious defects, in fact, should be tolerated.

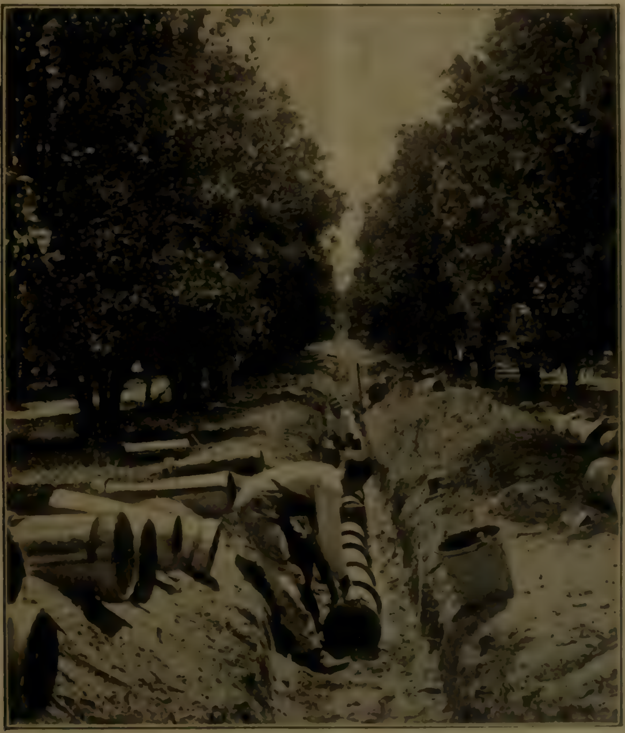

FIG. 10.—Laying vitrified-clay pipe to be used for irrigation.

The trench in which the pipe is laid should be dug about a foot wider than the pipe in order to allow the worker to calk and cement the joints carefully (fig. 10). To make the joints watertight it is first necessary to tamp them thoroughly with oakum, which centers the pipe and prevents cement from working into it. After the pipe is laid and the oakum well tamped in, a quantity of clean, sharp sand should be mixed thoroughly with an equal amount of cement,

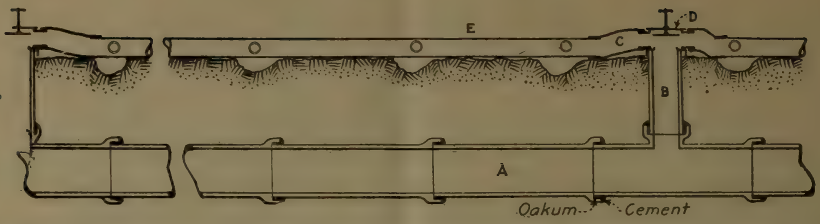

FIG. 11.—Cross-section of typical terra-cotta pipe system. A shows underground terra-cotta main pipe; B, terra-cotta riser; C, canvas connecting house; D, cast-iron valve; E, distributing pipe.

and the mixture wetted to a stiff consistency. This should be forced into the space between the bell and spigot and tamped firmly into place with a tamper, great care being taken to make sure that the underside of the joint is well cemented. When working with cement it should be remembered that only small batches should be mixed at one time and that these should be used quickly; it is not safe to use mixed cement which has stood longer than one-half hour.

The outlet valves or hydrants should be connected to standard vitrified-pipe tees by means of short pieces of clay pipe, the upper end being about flush with the ground surface. One type of valve which has given satisfactory service is made of cast iron and contains one or two large outlet spouts (fig. 11). The valve is cemented firmly to the pipe, making a convenient connection with the underground main. One advantage of such a system is that the pipe may be taken over ridges and across dips, if the total safe head is not exceeded. Another advantage is the ease with which the desired amount of water can be taken out at any convenient point. The valves usually are spaced about 30 to 100 feet apart, and the water is delivered to the furrows either by running it into open trenches and regulating the flow in each furrow with a shovel or by means of portable pipe containing slide gates. These pipes can be fastened to any valve in the field, and usually from 4 to 10 of them will be used simultaneously when irrigation is going on.

Another valve suitable for use with a sewer-pipe irrigation system may be fitted to either iron or sewer-pipe risers (fig. 12), and is capable of holding water under pressure up to 40 pounds per square inch, which would permit its use with steel mains under heavier pressure than that permissible with vitrified clay pipe. The pattern was designed by the Office of Public Roads and Rural Engineering to meet conditions encountered in the design of irrigation plants in the Eastern States especially, although utilizing principles which have operated in similar systems in California for many years. Except for being cemented to the inside of the pipe, this valve is connected to a vitrified-clay riser in the manner illustrated by figure 11. This valve is opened by turning the head, which permits the water to flow out freely on all sides. If portable or conductor pipe is to be used with the valve a portable cast-iron hood can be fastened to it by screwing it to the bolt on top of the valve after the lid has been opened. In every other respect the action of the valve is as illustrated by figure 11.

Both types have their advantages. The one just described is considerably cheaper than the other and can be placed a few inches below the surface of the ground, with only a board placed over it to protect it from injury during cultivation, but the portable hood is required if conductor pipe is used, which means a little more labor for the irrigator. However, the pipe must be carried from valve to valve anyhow, and the additional work of carrying the hood is not important. The spout of the hood can be faced in any direction with equal ease.

The use of vitrified clay pipe under pressure is of doubtful feasibility if the ground freezes to a depth of more than a foot below the surface. In any case, the top of the pipe should be at least a foot below freezing, as marked changes in temperature apparently cause considerable trouble in vitrified clay pipe even though the pipe be buried below danger from heaving ground. The uprights leading from the main to the surface must be reinforced, as heaving of the ground due to frost often will break the connection between the valves and the underground main. To prevent this trouble some farmers cover the valves with manure every winter; a better way is to place a larger pipe or tile around the riser and fill the space between the two with a mixture of tar and asphalt, this mixture being yielding enough to protect the riser from being pulled apart in freezing weather.

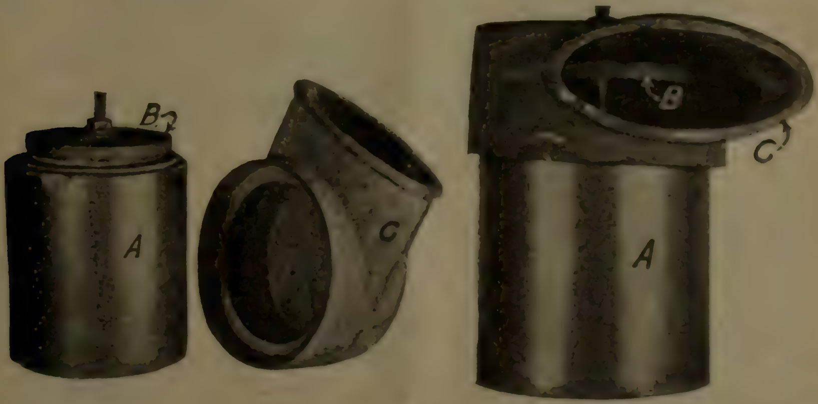

Fig. 12.—New design of cast-iron irrigation valve. *A* shows terra-cotta short piece which connects cast-iron valve *B* with underground main. *C* shows portable spout which is placed over *B* after valve has been opened. Spout *C* discharges into canvas hose connection to portable pipe when latter is used.

Because of the danger of freezing, vitrified clay pipe, when used in the Northern States, should be laid on such grades as will permit it to be drained readily. Drain cocks may be placed in the pipe at low places, these being made by cutting holes in the pipe with a chisel and setting in short pieces of 1-inch pipe connected to a cut-off valve. The drain is set near the bottom of the sewer pipe. If there is no natural drainage from the drain cock, it may be necessary to pump the water out before freezing weather sets in.

It is probable that less trouble would be experienced from expansion and contraction breaks in sewer pipe if every third or fourth joint were sealed with pitch. Where this is done the pitch is heated and poured into an oakum packing previously tamped into the joint. A collar is needed around the bell while the pitch is being poured. The pitch is hard enough to resist considerable pressure and is plastic enough to allow slight lateral expansion and contraction due to changes in temperature.

In northern localities the most common trouble with terra-cotta pipe is the breaking off of valves or the pulling off of vertical vitrified-clay risers from the tees in the main line. This has been overcome by the use of a cast-iron riser which tapers toward the top. The base of this tapered piece of pipe fits in the tee at the main as shown in figure 11, except that where this device is used a block of concrete is built around the tee in order to reinforce it. Trouble from heaving ground due to freezing usually is noticeable if a valve such as that shown in figure 11 rests on the ground. The valve should be either several inches above the ground or of the type shown in figure 11, this valve having no bell to protrude outside the pipe.

Often it is possible to use a combination system of vitrified clay pipe and open ditch, the pipe being used to carry water over rough or gravelly ground or over small ridges or hollows. The ditch then may be used to carry the water over parts of the farm where the grades are uniform and where open ditches would not be in the way of teaming. Water can be taken either out of the ditch or out of the pipe into the furrows, as suggested elsewhere in this paper. The combination often will mean a considerable saving in cost of the distributing system and usually be as efficient as one involving a much more complete use of pipe. This method calls for uniform grades in the field, however, and generally will require somewhat larger pipe than would be the case otherwise, as it will not be possible to have as much pressure as needed for the pipe alone. This method would not be advisable if water were to be pumped through any considerable vertical lift and if the soil to be irrigated were so sandy or porous as to cause heavy waste by seepage from an open ditch.

It is never safe to pump directly into a clay pipe system unless the pipe is reinforced; some sort of relief standpipe must be installed to equalize pressure. Such a standpipe should be placed near the upper end of the land to be watered, and should connect the pressure pipe from the pump with the vitrified clay pipe distributing system. Standpipes are open at the top, the elevation of which is a few feet above the top of the highest part of the irrigated ground. Thus, if all the valves in the field are closed and the pump is started the standpipe will permit the water to overflow instead of allowing the pressure to burst the clay pipe. A cheap and convenient standpipe is made by cementing together a few joints of vitrified clay pipe, as shown in figure 13. Sometimes standpipes or boxes are constructed in the field to act as diversion boxes. They usually are fitted with slide gates, and serve as air vents as well as means to shift water from one lateral to another.

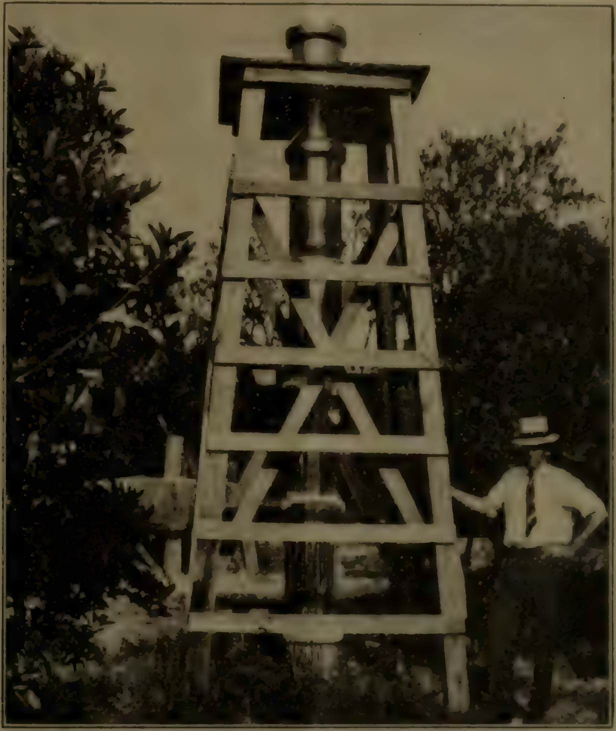

FIG. 13.—Relief standpipe at connection of iron discharge pipe and vitrified clay distributing lines.

Several kinds of pipes may be considered where conditions are such as to require considerable pressure (as, for instance, in connecting the pumping plant with the first standpipe). Cast iron probably is the most durable material, but is too costly for use on most farms, as its great weight makes freight and hauling charges excessive. Galvanized and black wrought-iron or wrought-steel threaded pipe is well adapted to high pressure, but long lines cost a great deal. Lightweight riveted steel pipe, both asphalted and galvanized, is adapted to most eastern conditions. The galvanized pipe is comparatively long lived, but the asphalted pipe often rusts out very rapidly. Wood pipe is not commonly used for irrigation in the humid sections, although well adapted to the purpose. Reinforced concrete pipe or reinforced drain tile or sewer pipe may be used in nearly all cases.

REINFORCED CONCRETE TILE AND SEWER PIPE.

High prices of steel and iron pipe and the inability of sewer pipe to stand any but very low heads have led this office to make tests on reinforced drain tile for high pressures. Reinforced concrete pipe has been used for many years in the West to carry water under high pressures. This pipe usually is of the larger sizes and requires special forms and skilled labor to make and lay it. Large-diameter reinforced-concrete pipe can be bought ready made in the East, but heavy freight charges usually prohibit the use of small sizes on the farm. Such pressure pipe is needed in nearly all cases where water is transported from pump to highest point of field, or in crossing deep dips or hollows. The tests, therefore, sought to discover some pipe which any intelligent workman could construct without expensive equipment. From tests made it seems entirely practicable for the farmer to install reinforced-concrete tile, which can be made without any expensive equipment and can be laid continuously in the trench.

Standard clay drain tile was taken first. Several sections of this were placed on a wooden spindle 10 feet long. The sections were then pulled together by six to eight wires running the same way as the pipe. These wires were tightened by means of bolts fastened at regular intervals in a board at the head of the tile. After the vertical wires were tight other wires were wound spirally around the tile, this being accomplished by turning the tile on the wooden core by means of a crank. The spacing of the wires was gauged by hand, one man turning the tile and another holding and guiding the wire. After the tile was wound it was removed from the core and then was ready to be covered with concrete. (Fig. 14.) Ten-foot lengths of tile from 4 to 10 inches in diameter could be handled easily by two men, as the wire held the tile together.

Instead of attempting to place concrete on the tile in a mold or by plastering, the tile was laid continuously in a trench which was cut to such a size that it would act as an outside form for the concrete. For ordinary work the trench was cut to the desired depth and about

3 inches wider than the outside of the tile and the bottom was rounded out to eliminate waste at the corners.

The best way to make a tight, leak-proof tile was found to be as follows: A rich mixture of concrete was made, no gravel or stone over one-half inch in diameter being used. Several inches of the wet mixture was placed in the bottom of the trench, and stones or pieces of broken tile were thrown in. The tile then was placed in the concrete and shaken up and down until the concrete was well stuck to the bottom and part way up the sides, the stone or broken tile preventing the tile sections from falling to the bottom of the trench. (See frontispiece.) The remainder of the concrete was placed in small quantities with a spade and tamped thoroughly, especially on the sides and around the joints. It was found that the careful placing and tamping of the concrete needed particular attention, in order that leaks might be prevented.

Tile from 4 to 10 inches in diameter was tested, and after the concrete had set it was found that pressures from 25 to 150 pounds to the square inch were needed to break the pipe, the lower pressures being for lean mixtures of concrete and very little reinforcing wire. For pressures up to 50 pounds per square inch for tile over six inches in diameter it was found best to use No. 8 wire wound spirally with about 1 inch between spirals. About eight horizontal wires running parallel to the axis of the pipe held the tile together and prevented temperature cracks in the finished pipe. For 4 and 6 inch tile No. 12 wire with the same wrap was found to answer. Concrete of 1–2–4 or 1–2–3 wet mixture was found to be best.

Such pipe as that described above would be satisfactory for nearly all purposes for surface irrigation where water is pumped. It can

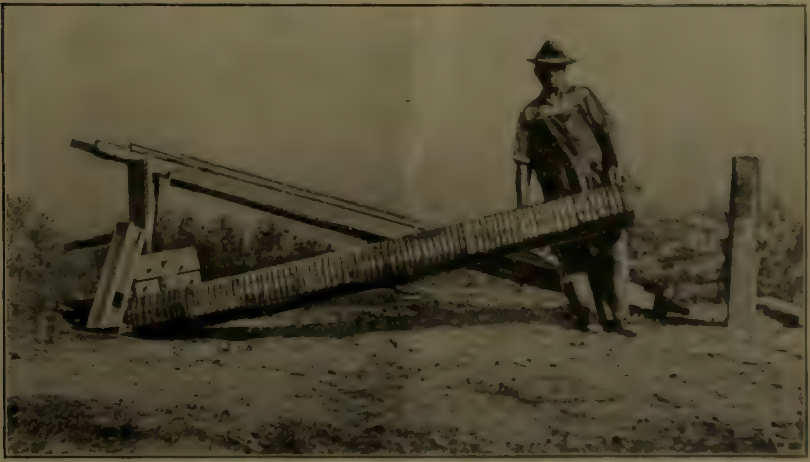

FIG. 14.—Wire-wound tile and wooden core.

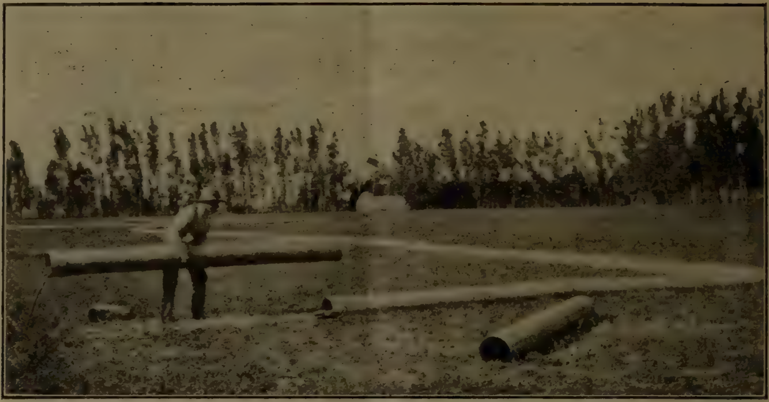

FIG. 15.—Use of portable galvanized-iron pipe in alfalfa irrigation.

be laid continuously for any length and should not cost more than half as much as steel or iron pipe.

Continuous reinforced concrete pipe was made by using the same general method as that just described, but the inside core was made of galvanized iron which could be wrapped with wire, placed in the trench, and, when after the core had been collapsed, removed about 45 minutes after the concrete had been placed around it. In order to accomplish this paper was wrapped around the collapsible core. The wire was wound around pieces of broken tile so as to stand out about 1 inch from the shell of the core and thus be on the outside of the concrete shell. This method requires close attention and should not be attempted on the average farm unless expert help is available. While the cost of this pipe is less than that of the reinforced drain tile, the difference is comparatively slight.

Another method of making pressure pipe is to use bell-and-spigot vitrified-clay sewer pipe and tamp and cement the joints before wrapping with wire. This pipe is more expensive than tile, but it is easier to make it leak-proof. A reinforced pipe of this sort would be particularly adapted to a sandy soil where it was necessary to use board forms on the sides of the trench, in order to use it for an outside form, where the soil would not permit laying the pipe continuously.

If necessary this pipe could be made in convenient lengths by using forms of wood or clay, the pipe being laid after the concrete had set. This method might be convenient where the pipe could not be laid continuously in the field on account of soil conditions or where freezing weather would prevent outside work. If this method were followed the joints of each length would need to be well wrapped with wire and the concrete poured around the pipe after the lengths had been laid in the trench. It also would be necessary to wrap the tile or pipe in shorter lengths, as the finished pipe would be several times as heavy as the wire-wrapped tile.

APPLYING THE WATER TO CROPS.

An understanding of the actual use of water in irrigation is as essential as the securing of the supply itself if the investment is to prove profitable. The irrigator must know how to make the water reach the plant roots.

USE OF PORTABLE PIPE AND HOSE.

Reference has been made to the use of portable pipe in spreading water which has been brought to the field by other means. If the soil to be irrigated is very sandy or the slope too flat to permit the water to run down the rows or furrows, the use of such pipe may be highly desirable. Portable pipe usually is made in 10-foot sections of light-weight galvanized sheet iron, one end of each section being slightly tapered, so that it may be pushed into the straight end of the following section to make a fairly tight joint. The pipe should be made of from 24 to 26 gauge galvanized sheet iron for 6-inch and smaller sizes and 22 to 24 gauge for 8 and 10 inch sizes. It is well to reinforce the ends with 18 to 20 gauge iron. Several firms make this pipe; many local tinners can make it or order it for the farmer.

In use, the pipe may be built up section by section, or the entire length may be built up first and the sections disconnected as irriga-

FIG. 16.—Six-inch cast-iron irrigation valve and hose connection to slip-joint pipe for irrigating orange grove.

tion proceeds. When the end of the field is reached the operation is repeated, with the pipe connected to the next valve, unless it is possible to water a number of rows from one valve. This pipe is very handy for irrigating hay crops and is used extensively in the West for irrigating alfalfa where the soil conditions are not favorable for wide flooding.

It is very difficult to carry water up a grade with the ordinary portable pipe, unless special joints are made. Some eastern irrigators have tried to prevent leaks at the joints of cheap portable pipe by laying the pipe on a grade, making use of portable wooden trestles. A better plan is to have the tapered and ringed ends of the sections extra long and heavy and to fit both ends of every joint with lugs. Two bolts can then be put through the lugs and the pipe drawn up with nuts, usually making a fairly tight joint. Western irrigators have used tarred cloth or burlap between the taper and the ring. Another way is to fit a shoulder on one end of the pipe and a rim on the other. A rubber gasket can be used in the shoulder and the pipe pulled together with bolts through lugs, as in the case of the slip-joint pipe.

Where a considerable grade must be climbed it sometimes is necessary to buy extra light weight spiral-riveted pipe and use a bolted joint. The time necessary to make connections renders this method too slow, however, if the pipe needs to be carried from place to place very often. The necessity of heavily reinforcing the ends of portable pipe in nearly all cases can not be overemphasized, as the pipe often is ruined by breaking of the seams when the sections are connected, bent, or twisted about during irrigation.

Hose is sometimes used instead of portable pipe to convey water, but, as a rule, hose should not be used, as it is not as durable as pipe and is worn out soon by being dragged over the field. It is subject also to attack by insects and rats or mice when stored for the winter, and is hard to handle unless the diameter is small and the lengths are short. Hose will drag down tender plants unless the farmer is very careful in handling it. If used at all it should be dried out after each irrigation and stored in a dry place.

For small quantities of water ordinary garden hose can be used. Condemned fire hose, up to 2½ inches in diameter, sometimes can be bought cheaply. The connections on this hose are of the quick-turning brass variety. Fifty-foot lengths usually are to be advised. Two to 8 inch hose may be home-made cheaply from strips of heavy duck or canvas by sewing a double seam with very heavy thread. A local harnessmaker or cobbler, having suitable machines for such work, should be able to make a strong hose of this sort. Often it is advisable to treat canvas hose with tar, varnish, or paint to increase its life and render it more nearly leakproof.

Devising connections for home-made hose often presents difficulties. A fairly good joint may be made in several ways, probably the cheapest being to wire the ends to short pieces of lightweight galvanized-iron pipe, one end of which is tapered and the other straight. The lengths then are joined as in the case of conductor pipe. If any appreciable pressure is to be applied these joints should be bolted together as described for the pipe. A stronger joint can be made by tying the hose around short pieces of standard threaded pipe, a coupling being placed on one end of each pipe. This joint will stand considerable pressure without leaking. Regular brass fire-hose coupling can be bought, but the cost of this for the larger sizes is too high to be considered.

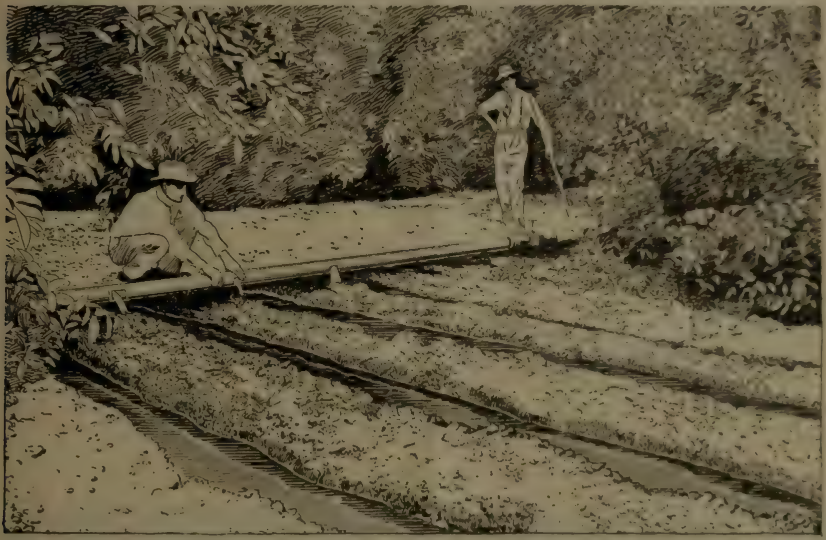

FIG. 17.—Furrow irrigation from portable distribution pipe attached to hydrant of underground main.

FURROW IRRIGATION.

Where the use of portable pipe does not appear to be necessary irrigation as practiced in the East usually is effected by diverting the water directly from the distribution system into field furrows (figs 17, 18, and 19). A sandy loam underlain with a comparatively impervious subsoil probably is the easiest and most satisfactory soil to irrigate, provided the slope of the land is favorable. Such a soil with a grade of 4 inches to 1 foot per 100 feet will allow water to reach the plant roots and still run a considerable distance down open furrows. The amount of moisture in the ground before irrigation and the kind of crop grown will go far in determining the quantity

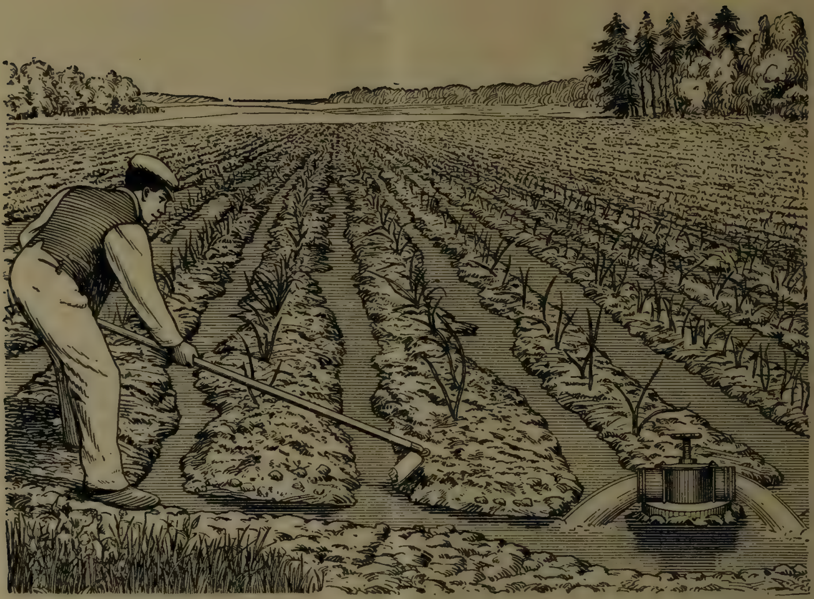

FIG. 18.—Furrow irrigation in Georgia. Water being delivered from cast-iron valve which is connected to underground vitrified clay pipe.

of water required. In light, loamy soil this may be applied by running water for a few hours in each furrow, but a much longer time will be required for a heavy soil. Usually water should be let into each furrow and made to reach the lower end as quickly as possible; the quantity entering each furrow then can be diminished, enough still being allowed to enter so that a sufficient supply will reach the end of the furrow. This method may be expected to effect a uniform distribution of the water.

The irrigator can determine whether the water has run long enough by digging down to the roots of the plants and observing how deep the water has percolated. If it has gone below the root zone a waste is taking place. It is better not to wet the surface of the ground in the row of the plants, but to allow the water to seep into the soil from the furrows, which will prevent the soil in the rows from baking and cracking.

Very sandy soil usually requires a large head of water for each furrow, as it is necessary to get the water to the end of the furrow quickly in order to prevent loss by deep percolation. The slopes of the ground will determine to a great extent the maximum quantity which may be used. If steep slopes are encountered the soils will wash badly and if the ground is too flat the water will not reach the ends of the furrows, but form puddles at the upper ends. The former situation may be controlled by letting smaller quantities of water into the furrows, or by decreasing their grades by running them diagonally across the field. For very flat grades it often is necessary to use the portable pipe or hose described on page 27.

Heavy clay soils usually require small heads of water in each furrow and the water must be run a longer time. Such soils usually call for less water for an irrigation and also retain water better than the sandy type. However, the irrigator must watch each furrow very carefully or he will waste water at the lower end. For such soil it is especially desirable to have some apparatus that may be adjusted carefully so that the water will be equally divided among a large number of furrows.

Cultivation is very necessary after each irrigation, unless the plants completely shade the ground, and should follow irrigation as soon as the condition of the soil will permit.

Some irrigators plant in the furrow which has been wetted down previously by irrigation; others plant between furrows that are close together, allowing water to run long enough to soak the seed bed thoroughly.

Often furrows 400 to 600 feet long (and sometimes even longer) may be used satisfactorily, but generally shorter lengths are advisable. If the furrows are found to be too long it may be necessary to run another pipe line or ditch parallel to the head one, about half-

FIG. 19.—Furrow irrigation of sweet potatoes from open head ditch

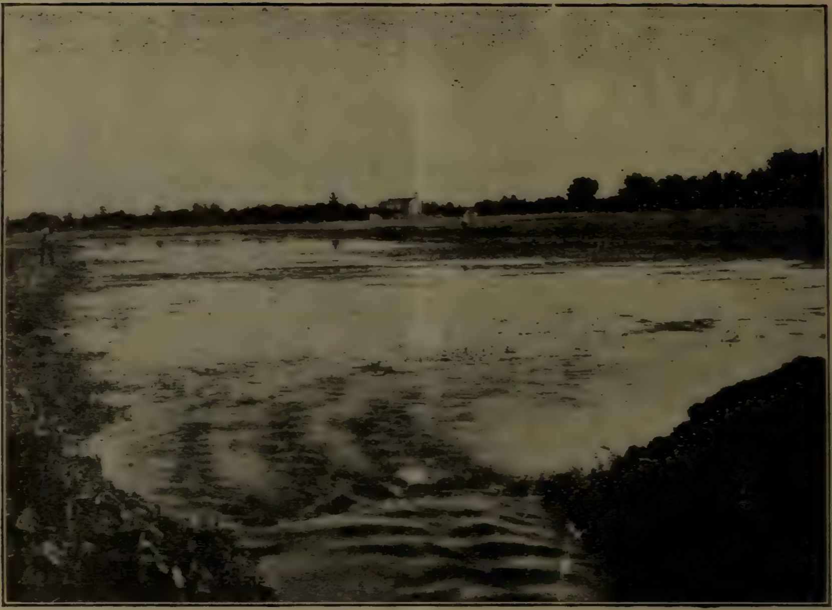

FIG. 20.—Flooding between borders with large heads of water.

way down the furrows. In small market gardens the furrows often are not over 100 feet long. These short lengths allow smaller quantities of water to be let into each furrow, and permit close planting.

Where a combination of spray and furrow systems seems necessary, the former should be used to irrigate seed beds or closely planted garden truck, and the furrow system for such crops as potatoes, corn, rhubarb, celery, and berries, after they have been set out from the seed beds. It may be practicable to eliminate the spray system by planting the seeds in beds 3 to 10 feet wide which may be irrigated from furrows cut between them. The water should be kept in the furrows long enough to percolate laterally across the beds. This method is practicable on land that is nearly level, and where there is a light surface soil underlain with clay. Furrow irrigation of seed beds on heavy clay soils is very difficult, and requires considerable patience and experience.

When flooding methods are resorted to, it usually is necessary to lay out level beds of convenient size and flood with large heads of water (fig. 20); or in some cases crops may be flooded by cutting the head ditch at convenient points and letting the water run freely over the land (fig. 21). The former method (which has not been considered in the foregoing discussion) is used in irrigating rice and cranberries and the latter for grain or meadows.

COST OF IRRIGATION.

The most important item of expense for irrigation in the humid sections is the cost of installation. This may be only a few dollars per acre where a gravity flow is developed and water is distributed to the field entirely through open ditches. In a number of such cases, especially in the South, considerable areas have been watered for $10 or less per acre. These systems involve merely short gravity ditches leading directly from streams or flowing wells. A more expensive plant is necessary where the water supply must be stored. Plants utilizing flowing wells that yield only 30 to 40 gallons per minute have been used to irrigate 10 to 20 acres, with the assistance of a storage reservoir constructed in clay soil.

Irrigation plants involving low pumping lifts and open-ditch distribution systems also are comparatively cheap. Such a plant should irrigate a 20-acre field adjacent to a stream for $15 to $20 per acre, if the pumping lift is, say, 25 feet. If a vitrified-clay pipe distribution system were used, the irrigation of the same plat probably would cost $40 to $60 per acre. If the pumping lift were 40 to 60 feet, and the field, say, 1,000 feet from the water supply, the total cost easily could be double that given above, although the cost of the distributing system should be about the same as for the system with the lower lift. For a complete system so situated it would be safe to figure a cost of $65 to $85 per acre. If a larger acreage were to be watered, the cost would be somewhat less per acre. Where wells

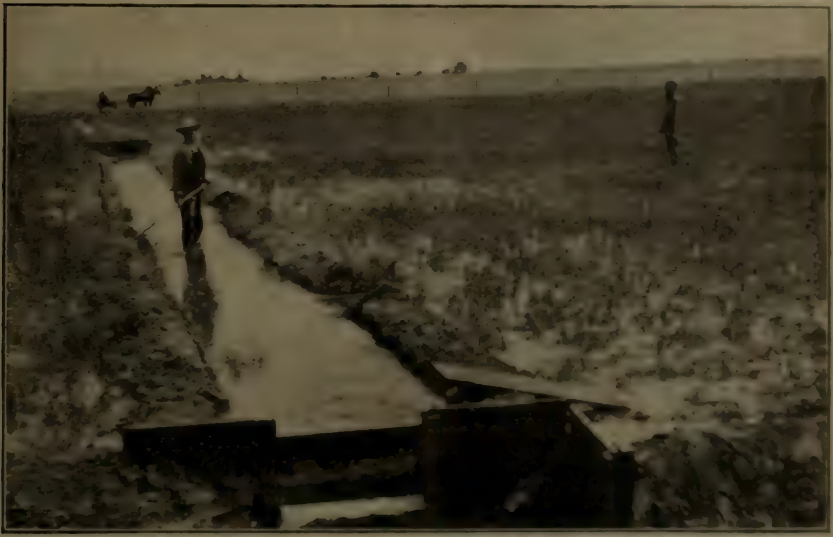

FIG. 21.—Flooding alfalfa field from open field ditch.

must be bored and deep-well pumps installed, an irrigation system may cost $100 or more per acre. A deep-well outfit usually is too costly for furrow irrigation, unless crop, soil, and market conditions are very favorable.

The following cost tables for pipes of various kinds adapted to use in surface irrigation, together with the pump cost figures shown in Table 2, page 16, and the discussion of engine costs on page 15, should enable a prospective irrigator to estimate, at least approximately, the cost of a complete irrigation system. The prices shown in Table 3 are subject to wide fluctuation.

TABLE 3.—*Approximate cost, per foot of length, of pipe adapted to surface irrigation systems.*

Diameter.	Wrought steel, black.	Wrought steel, galvanized.	Riveted steel, galvanized.	Cast iron.	Vitrified clay.
Inches.	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*
¾	0.032	0.042	....	....	....
1	.046	.062	....	....	....
1¼	.064	.084	....	....	....
1½	.076	.101	....	....	....
2	.102	.135	....	....	....
2½	.161	.214	....	....	....
3	.210	.28	0.20	....	....
4	.31	.41	.25	0.24	0.06
5	.42	.56	.30	....	....
6	.55	.72	.40	.40	.09
7	.75	1.02	.45	....	....
8	.79	1.06	.52	.55	.15
10	1.10	1.70	.70	....	.20
12	1.40	2.00	.85	1.00	.24
14	....	....	1.00	....	....
15	....	....	1.25	....	.38
18	....	....	1.45	1.70	.50

Cast-iron valves for vitrified clay pipe cost $2 to $4 each, and laying and trenching should cost from 4 cents to 6 cents per foot, for the sizes ordinarily used in the east; the higher cost will be in clay soil, where trenching is expensive. Field systems for vitrified-clay pipe installed in the humid sections have cost from $20 to $50 per acre. The cheaper systems sometimes use portable pipe to carry water to some of the higher ridges.

The operating cost of most furrow-irrigation plants in the humid sections is not great, as crops ordinarily need to be irrigated only a few times to carry them through periods of drought. The interest on first cost and the depreciation of the plant must be considered carefully, and often are the deciding factors in determining the feasibility of a pumping outfit. Yearly interest and depreciation of from 10 to 20 per cent is common; probably an average of 15 per cent would hold for most surface-irrigation plants. For example: If a plant cost $75 an acre to install, and the operating cost was $10 an acre per year, it would be necessary to add $11.25 for interest and depreciation, making a total yearly cost of $21.25.

This would mean that the crops irrigated should yield a net profit of $21.25 per acre more than those raised on the same land without irrigation before any profit could be accredited to the irrigation plant. Water may be worth many times this amount for some crops and much less for others. Local conditions control allowable costs of irrigation to such an extent that permissible limits of construction expense can not be given here.

INFORMATION NEEDED IN DESIGN OF A PLANT.

The Department of Agriculture receives many letters asking for information regarding irrigation in eastern localities. Before helpful advice can be given in response to such requests it is necessary to have the following information:

1. Acreage to be irrigated.
2. Character of the soil.
3. Source of water supply; estimated quantity available. (If a well, the size and type of well, distance to water, and probable draw down when pumped.)
4. Distance from water supply to land to be irrigated.
5. Difference in elevations between land and water supply.
6. Crops to be irrigated.
7. The general grades of the land to be watered.
8. A sketch showing prevailing grades of the land to be irrigated, location of the water supply, etc. It will be sufficient if this indicate approximate contours and directions of slope (by arrow), with fall in inches per 100 feet.

PUBLICATIONS OF THE DEPARTMENT OF AGRICULTURE RELATING TO IRRIGATION.

AVAILABLE FOR FREE DISTRIBUTION.

Sugar-Beet Growing Under Irrigation. (Farmers' Bulletin 567.)
Drainage of Irrigated Lands. (Farmers' Bulletin 805.)
Construction and Use of Farm Weirs. (Farmers' Bulletin 813.)
Irrigation of Grain. (Farmers' Bulletin 863.)
Practical Information for Beginners in Irrigation. (Farmers' Bulletin 864.)
The Use of Windmills in Irrigation in the Semiarid West. (Farmers' Bulletin 866.)
Irrigation of Orchards. (Farmers' Bulletin 882.)
Experiments With Crops Under Fall Irrigation at Scottsbluff Reclamation Project Experiment Farm. (Department Bulletin 133.)
Wood Pipe for Conveying Water for Irrigation. (Department Bulletin 155.)
Experiments on Economical Use of Irrigation Water in Idaho. (Department Bulletin 339.)
Irrigation in Florida. (Department Bulletin 462.)
Spray Irrigation. (Department Bulletin 495.)
Mulched-Basin System of Irrigated Citrus Culture and Its Bearing on Control Mottle-leaf. (Department Bulletin 499.)
Agriculture on Government Reclamation Projects. (Separate 690 from Year Book 1916.)
Pumping for Irrigation on the Farm. (Separate 703 from Year Book 1916.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Irrigation in Field and Garden. (Farmers' Bulletin 138). Price, 5 cents.

How to Build Small irrigation Ditches. (Farmers' Bulletin 158.) Price, 5 cents.

Irrigation of Alfalfa. (Farmers' Bulletin 373.) Price, 5 cents.

Gate Structure for Irrigation Canals. (Department Bulletin 115.) Price, 20 cents.

Concrete Lining as Applied to Irrigation Canals. (Department Bulletin 126.) Price, 10 cents.

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Irrigation in Arizona. (Office of Experiment Stations Bulletin 235.) Price, 20 cents.

Use of Underground Water for Irrigation at Pomona, California. (Office of Experiment Stations Bulletin 236.) Price, 20 cents.

Irrigation in California. (Office of Experiment Stations Bulletin 237.) Price, 10 cents.

Storage of Water for Irrigation Purposes: Part 1, Earth-fill Dams and Hydraulic-fill Dams. (Office of Experiment Stations Bulletin 249.) Price, 20 cents.

Storage of Water for Irrigation Purposes: Part II, Timber Dams and Rock-fill Dams. (Office of Experiment Stations Bulletin 249.) Price, 15 cents.

Irrigation from Snake River, Idaho. (Office of Experiment Stations Circular 65.) Price, 5 cents.

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FARMERS' BULLETIN 900
United States Department of Agriculture

HOMEMADE FRUIT BUTTERS

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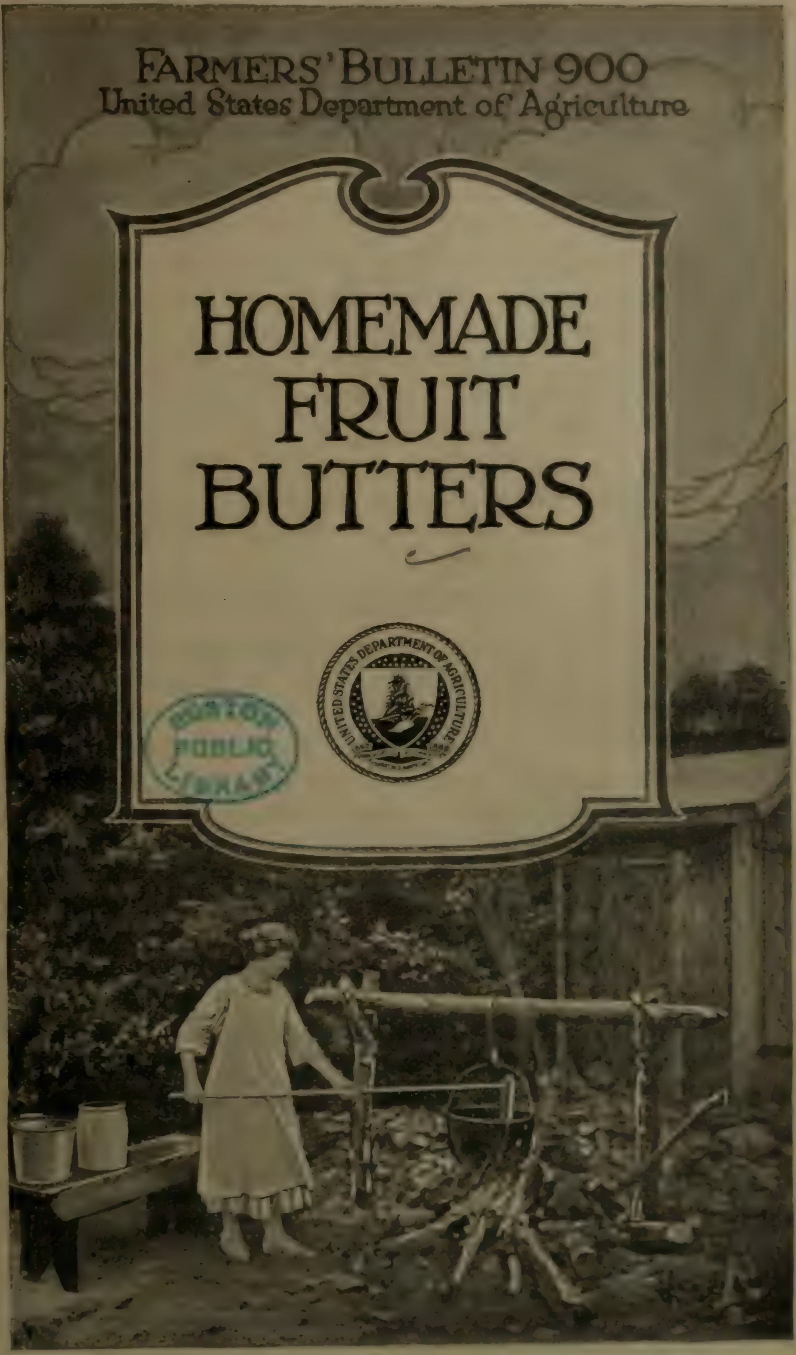

THE OBJECT of this bulletin is not to cover the entire range of products which may be made from fruits nor to publish a long list of recipes, but rather to revive an interest in a few of the more common home fruit products easily made and relished by most people.

The various butters considered in the following pages have all been made and tested in one of the laboratories of the United States Department of Agriculture and can be recommended as good, wholesome, home-prepared fruit products.

The principal new features presented here are the short time in which apple butter may be made and the adding of the peeled and sliced apples to the fresh cider without first boiling down the cider.

Those who do not grow fruit may take advantage of heavy supplies of fruits in the markets to buy cheaply and also to help conserve foods which might otherwise be wasted.

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief
Washington, D. C. March, 1920

[illegible]
June [illegible]

HOMEMADE FRUIT BUTTERS

By C. P. Close,
Pomologist, Office of Horticultural and Pomological Investigations.

CONTENTS.

	Page.
Importance of fruit conservation	3
Necessary equipment	3
Apple butter	3
Apple butter with cider	4
Apple butter without cider	5
Apple butter with grape juice	5
Apple butter with lemons	5
Apple butter with plums	5
Apple butter with rhubarb	5
Pear butter	6
Peach butter	6
Peach butter made with dried and canned peaches	6
Peach butter with lemon juice	6
Plum butter	7
Garfield butter	7
Sterilization of containers for fruit butters	7

IMPORTANCE OF FRUIT CONSERVATION.

WITH the present need of real food conservation, such part of the fruit crop as can be made economically into a palatable product should be saved. Although canning and drying are always largely practiced as a means of saving perishable fruits, there are other ways of utilizing a portion of them to add variety to the menu and volume to the larder. As much of these fruits as can be handled satisfactorily should be used in making fruit butters. While it is desirable to have only good grades of fresh fruits for making these products, the sound portions of inferior fruit may be used with perfect success.

NECESSARY EQUIPMENT.

The usual utensils in almost daily use in every kitchen are all that are needed in the making of fruit butters in small quantities. It is desirable, but not absolutely necessary, to have an enamel-lined, aluminum, or other good preserving kettle, such as is kept for fruit-cooking purposes only. Other utensils needed are a colander, wire sieve, potato masher, measuring cups, knives, and pans.

The large iron and copper kettles, used so much on the farms in the past in making considerable quantities of apple butter out of doors (see title-page illustration), are still in use in many sections of the country.

APPLE BUTTER.

Apple butter has probably not lost its old-time popularity, but it does not seem to be made in such generous quantities nor in so many homes as formerly. There is no better way to use good apples and the sound portions of windfall, wormy, and bruised apples than to make them into butter, either in small or large quantities.

While almost any apples will make good apple butter, those which have a distinctively rich tart flavor and good cooking quality are most satisfactory. Such old standard varieties as Northern Spy, Rhode Island Greening, Tompkins King, and Smokehouse are excellent for this purpose. It has been found in recent tests by the United States Department of Agriculture that the summer varieties make as rich and snappy apple butter as the fall and winter varieties. Varieties of coarse texture naturally make a rather coarse product unless put through a colander or wire sieve after first being made into apple sauce before adding them to the cider. Sometimes sweet apples are used with tart apples, the usual proportion being one-third of the former to two-thirds of the latter. Overripe apples are not desirable, but if they must be used add a little vinegar to give some snap to the butter. The proportion of vinegar required must be determined by the taste.

It has been accepted generally that the sweet cider must be boiled down at least one-half before the apples are added and cooking begun and that slow cooking for hours was absolutely necessary. This, however, is not necessary; in fact, it is a loss of time and fuel to boil down the cider first and then cook the apples in it for a long time. Just as high a grade of butter will result by adding the apples to the unboiled cider and cooking rapidly until finished. Small lots of apple butter may be made in one hour, or less, by putting the apples into sweet cider and cooking as fast as is safe without scorching. Large quantities take a longer time, but may be cooked as rapidly as possible. Strict attention must be given to stirring, in order that the butter may not scorch and stick to the kettle.

Apple butter with cider.—Either fresh cider or commercial sterilized cider may be used. The usual proportion of peeled and sliced apples and cider is gallon for gallon, but from one-half to three-quarters of a gallon of cider to a gallon of peeled and sliced apples will give a rich product if the apples are good cookers. Less than half as much cider as prepared apples is likely to make an apple sauce rather than a butter, unless it is cooked very slowly for four to six hours.

Continue the cooking until the cider and apples do not separate and the butter, when cold, is as thick as good apple sauce. Determine the thickness at frequent intervals by cooling small portions.

If sugar is used, add it after the cooking of cider and apples is about two-thirds done. About a pound of either white or brown sugar is the usual proportion per gallon of apple butter, but more or less (or not any) may be used, to suit the taste.

Apple butter is spiced according to taste, about half a teaspoonful each of ground cinnamon, cloves, and allspice being used for each gallon. These are stirred into it when the cooking is finished.

Vanilla extract added after the spices are stirred in improves the quality and adds to the snappiness of the butter. Use from 2 to 4 teaspoonfuls per gallon of butter, according to taste.

Apple butter without cider.—Good apple butter is often made without the use of cider. Acid apples of good quality are best for this purpose, as they make a snappy product. Add enough water to the peeled and sliced apples to make a thin apple sauce, cook very slowly, or simmer, over a low fire for three or four hours and stir often. Brown rather than white sugar is usually used, being added when the cooking is two-thirds done. The sugar which settles at the bottom of a barrel of New Orleans molasses is excellent for this purpose. A pound per gallon is usually sufficient; but this amount is a matter of taste, as is also the amount of cinnamon, allspice, cloves, and vanilla to be added when the cooking is done.

Apple butter with grape juice.—If a grape flavor is desired in apple butter it may be obtained by the use of grape juice. To each gallon of peeled and sliced apples, cooked into sauce and strained, add 1 pint of grape juice, 1 cup of brown sugar, and one-quarter of a teaspoonful of salt. Cook slowly and stir often for two hours, or until of the desired thickness; then stir in 1 teaspoonful of cinnamon.

Apple butter with lemons.—Slice four lemons, cover with water, and let stand over night. Next morning put them in a preserving kettle with 8 pounds of apples, pared, cored, and sliced. Cook for one hour, add 3 pounds of sugar, and cook slowly with frequent stirring one and one-half hours longer, or until of the proper thickness.

Apple butter with plums.—An exceedingly rich and snappy butter is made with apples and plums. Use 1 measure of plums to 2 measures of peeled and sliced apples. Wash and cook the plums and rub through a strainer or colander to get out the pits. Cook the apples into sauce, add the stewed plums, and continue cooking an hour or two or until of the right consistency. When two-thirds cooked, add 2 pounds of sugar per gallon. When finished use spices and vanilla according to taste.

Apple butter with rhubarb.—A fairly satisfactory butter, or perhaps relish, is made of apples and rhubarb. Peel and cut the rhubarb into short pieces and use from one-eighth to one-quarter as much as of peeled and sliced apples. Place the rhubarb and the apples together in the kettle and add enough water to make a rather thin sauce. Cook until the proper thickness. Use sugar and spices, as mentioned for apple butter with cider. This must be sterilized and tightly sealed at once, because molds attack and grow in it so readily.

PEAR BUTTER.

Pear butter is made like the apple butter without cider. Use pears ripe enough to cook up well. Peel, core, and slice them; put in a preserving kettle with a little water and cook slowly until soft. Then add the sugar, 1 cup to 1 quart of sliced pears, and continue cooking very slowly, with frequent stirring, for one and a half to two hours. The butter should then be smooth and of the consistency of thick apple sauce. Stir into the hot butter a little lemon juice, with ginger, cinnamon, or other spices to taste. Pack while hot in hot sterilized containers and cover with paraffin, or sterilize with steam as directed for apple butter.

PEACH BUTTER.

Put the peaches in a wire basket and dip them in boiling water a few seconds or until the skin slips; test by raising the fruit out of the water and rubbing the skin between the fingers. Dip the peaches into cold water, peel, and pit them. Well-ripened freestone varieties are best. Mash the pulp and cook it in its own juice without adding water. If it is rather coarse, put it through a colander or coarse wire sieve to make a butter of fine texture. To each measure or pound of pulp add a half measure or half a pound of sugar, cook slowly, and stir frequently until the product is of the desired thickness. The sugar may be added before cooking begins, if desired. The meats of several pits may be cooked either whole or sliced in each gallon of butter. While still hot, pack in sterilized jars or glasses with tight-fitting tops and sterilize like apple butter or cover with hot paraffin.

Peach butter made with dried and canned peaches.—When ripe peaches are not available, peach butter can be made from dried and canned fruits. To each 4 pounds of dried peaches use 2 quarts of canned peaches. Soak the dried peaches in water several hours and cook until tender. Add the canned peaches and rub the pulp through a colander or wire sieve. Stir 2½ pounds of sugar into this pulp and cook slowly, stirring often, for two hours or until of the right thickness. Pack while hot and cover with hot paraffin, or sterilize like peach butter.

Peach butter with lemon juice.—Pare, pit, and slice 15 pounds of peaches, put in a preserving kettle, and bring slowly to a boil in their own juice. Cook 45 minutes and add 5 pounds of sugar. Cook 15 minutes longer, add the juice of 1 lemon, and boil 1 minute longer. Boil slowly and stir often. Pack while hot and cover with hot paraffin, or sterilize like peach butter.

PLUM BUTTER.

Wash the plums, place them with a little water in a preserving kettle, and cook until soft. Then separate the skins and the pits by rubbing the pulp through a colander or a coarse wire sieve. In the case of large freestone plums it will probably be easier and quicker to dip the fruit into boiling water a few seconds until the skins crack, then dip into cold water, so that the skins can be readily slipped off, the flesh split open, and the pits removed.

If the plums are very juicy, the pulp put through a colander will be quite thin and ought to be boiled down to thicken it somewhat before the sugar is added. For each measure of pulp, whether put through the colander or not, use a half to three-fourths of a measure of sugar and cook slowly with frequent stirring until the butter is as thick as desired. If a tart butter is favored, less sugar should be used. Cinnamon, allspice, and cloves should be added to suit the taste when the cooking is finished.

Plum butter should be packed hot in hot sterilized jars or glasses and then covered with hot paraffin, or else sterilized as directed for apple butter.

GARFIELD BUTTER.

Take two-thirds plums and one-third peaches. Pare, pit, and slice the peaches, and if the plums are freestones remove the pits. Cook the peaches and plums together slowly until soft and rub through a colander or coarse sieve. If the plums are clingstones the pits are removed by this operation. To each measure of pulp add three-fourths of a measure of sugar, cook slowly, and stir often until of the right thickness. Pack hot and cover with hot paraffin, or sterilize like peach butter.

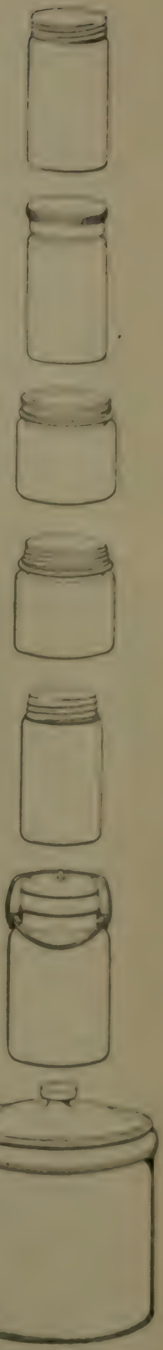

FIG. 1.—Six types of glass containers and a stone jar for storing fruit butters.

STERILIZATION OF CONTAINERS FOR FRUIT BUTTERS.

The ordinary glass or stone jars (fig. 1), hermetically sealed stone jars (fig. 2), or any glass or stoneware containers with or without air-tight covers may be used for holding fruit butters. Sterilize all containers and pour in the boiling hot butter. If the containers do not have air-tight covers, pour hot melted paraffin over the butter at once to seal the top and keep out molds. Sterilize filled containers with tight covers on by setting them in a vessel fitted with a false bottom and deep enough to hold them, pour in a little water, put on the cover to hold the steam, and set over the fire. Begin to count time when the steam starts to escape, and after 5 minutes for quart or smaller sizes, 10 minutes for half-gallon sizes, and 15 minutes for gallon sizes, take the containers out to cool; then set them away for future use. Do not disturb the covers until the fruit butter is to be used. If the covers do not fit tightly, place waxed or oiled paper in them to make a tight fit before sterilizing. This sterilizing is for the purpose of preventing any molding, spoiling, or infection of the top layer of fruit butter and also to take the place of paraffin, which is now quite expensive.

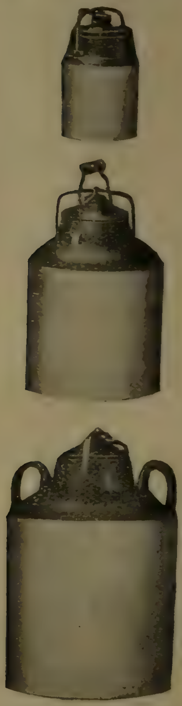

FIG. 2.—Three sizes and types of hermetically sealed crockery jars. These are satisfactorily used for storing fruit butters.

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